Report of the Chief

of the

Bureau of Entomology

and Plant Quarantine

1950

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Administration

Report of the Chief of the Bureau of Entomology and Plant Quarantine

Agricultural Research Administration, 1950

LETTER OF TRANSMITTAL

UNITED STATES DEPARTMENT OF AGRICULTURE,
Washington, D. C., September 15, 1950.

DR. P. V. CARDON,
Agricultural Research Administrator.

DEAR DR. CARDON: I submit herewith a report of the work of the Bureau of Entomology and Plant Quarantine for the fiscal year ended June 30, 1950.

Sincerely yours,

AVERY S. HOYT,
Chief.

CONTENTS

THE WAR against insect pests of man, his livestock, and his crops will probably never be won, if victory means eradication, but man is subduing these enemies and for the most part is keeping them under control. For many years it has been the Bureau's responsibility to wage this war by protecting American agriculture against destructive insects and plant diseases—through research to find means of destroying these pests, direction of operations to control them, and enforcement of quarantines to prevent them from spreading.

In the last few years many new insecticides and new methods of applying them have been developed, particularly for use in large-scale operations, and new regulations have been authorized for preventing their spread and providing more adequate protection against foreign pests. However, new problems are continually arising. Rapid transportation, particularly by aircraft, makes it easier for new pests to reach our shores or spread to new areas within the country; the expansion of agriculture has provided larger areas for crop pests to invade; the extensive use of insecticides may kill off natural enemies that previously kept them in check; and a new problem is presented in the recent discovery that insects can develop resistance to insecticides that have been effective against them.

During the past year the Bureau has expanded its activities against the oriental fruit fly and the citrus blackfly, two foreign insect pests that have threatened this country's fruit-growing industry. The oriental fruit fly has recently become established in Hawaii as a destructive pest of fruit in these islands, and every effort is being made to prevent it from reaching the mainland of the United States. Intensified research during the year has verified previous reports of its hardiness and destructiveness, but with more effective quarantine measures and progress made in developing weapons with which to fight the pest the outlook is much brighter than it was a year ago. The citrus blackfly is spreading north through citrus groves in Mexico in the direction of similar groves in our Southwestern States.

Increased funds for surveys to keep track of its movements in Mexico were made available during the year. Close watch is also being kept at our quarantine stations at the Mexican border, and studies are being made to find the most effective means of combating the pest.

An enemy that has recently gained a foothold in this country is the golden nematode of potatoes. As yet the infestation is confined to Long Island, N. Y., but the Bureau is cooperating with the State in taking strong measures to stamp out this infestation and prevent it from spreading to other potato-growing sections.

The widespread grasshopper outbreak in the West and Middle West in the summer of 1949 held an important place in the Bureau's control program, which was conducted in cooperation with State agencies and landowners. New baits and sprays were applied, chiefly by airplane, over large areas. Other aerial operations were undertaken against the gypsy moth in the Northeastern States and the spruce budworm in Oregon. Outstanding progress was also made in campaigns to control the white-fringed beetle and the sweetpotato weevil in the South.

Several new insecticides have been tested which show promise against various pests, and toxicological studies on insecticides have been continued in cooperation with the Food and Drug Administration and other agencies. Improved procedures for quarantine enforcement were authorized during the year.

Leland O. Howard, first Chief of the Bureau of Entomology, died on May 1, 1950. Dr. Howard entered the Department of Agriculture in 1878 as a student assistant in what was then the Division of Entomology, and when the Bureau of Entomology was established in 1904 he became its Chief. He was one of the first to crusade against insect pests, particularly the house fly and the malaria mosquito, and he achieved an international reputation in the field of insect control. Upon his retirement as Chief in 1927 he remained with the Bureau until 1931, and for many years thereafter he visited the library twice a week to keep abreast of progress in entomology.

After the death of Percy N. Annand, Avery S. Hoyt was appointed Chief of this Bureau on April 26, 1950. He had been Associate Chief since 1941.

On October 1, 1949, Ralph A. Sheals was made Assistant Chief of the Bureau in charge of administration, succeeding Edmund Stephens, who had returned to the Bureau of Plant Industry, Soils, and Agricultural Engineering with which he had formerly been connected. Mr. Sheals has long been connected with this Bureau, and was for many years in charge of the Division of Gypsy and Brown-Tail Moths Control.

B. M. Gaddis, in charge of the Division of Domestic Plant Quarantines since 1934, died on August 25, 1949. He was succeeded by Roy K. Richmond, assistant Division leader.

Frank C. Craighead, who headed the Division of Forest Insect Investigations for 27 years, retired on May 1, 1950.[1]

---

[1] James A. Beal became leader of this Division on August 20, 1950.

DR. PERCY N. ANNAND

Dr. Percy N. Annand, Chief of this Bureau since 1941, died on March 29, 1950.

Dr. Annand began his career in the Department in 1929, as an entomologist charged with the study of the beet leafhopper, a destructive agricultural pest in the West. His research in California and Idaho supplied important information on the ecology of this insect. In 1939 he came to Washington to an administrative position. From 1934 to 1937 he was head of the Division of Cereal and Forage Insect Investigations, in which capacity he directed the first large-scale grasshopper control campaign in the West. During the next 2 years he served as coordinator of all research work in the Bureau, and in 1939 was named Assistant Chief in charge of research. After the death of Dr. Lee A. Strong in June 1941, he was appointed Chief.

At that time World War II was well under way, and since disease-carrying and crop-destroying insects were important among our enemies, it became Dr. Annand's responsibility to marshall the Bureau's forces to combat them. This he did with calmness and dispatch. During the war and postwar years the control of injurious insects has undergone revolutionary changes. Many new insecticides have been developed, as well as new equipment and methods of applying them, especially by aircraft. Coordination of these various phases was efficiently and effectively accomplished by Dr. Annand. To prevent new pests from reaching this country, in view of increased air traffic from all parts of the world and the heavy movement of troops and equipment back from the war areas, posed problems which he met with equal forthrightness.

In all his relationships, both within the Bureau and outside, Dr. Annand displayed remarkable ability to grasp problems and to make constructive suggestions for handling them. He showed an interest in the work that each member of the Bureau was doing and was ever ready to give praise and show appreciation for a job well done. The results of the Bureau's work as set forth in this report are a tribute to his leadership.

FRUIT AND NUT INSECTS

Expanded Oriental Fruit Fly Research Shows Progress

The expanded program of research on the oriental fruit fly in Hawaii has progressed rapidly during the year that it has been in operation. This insect, originally from the South Pacific, has in the last few years become a serious pest of fruits and vegetables in Hawaii. The purpose of these investigations is to obtain information that would form the basis of any program of control or eradication should this fruit fly be found in the continental United States. Although much of the

work is intended primarily for the benefit of mainland agriculture, it will also be of great benefit to Hawaiian growers. The investigations are being conducted in cooperation with the University of California, the California Department of Agriculture, the Hawaii Agricultural Experiment Station, the Territorial Board of Commissioners of Agriculture and Forestry, the Pineapple Research Institute, and the Hawaiian Sugar Planters' Association.

Studies on the treatment of fruits and vegetables prior to shipment were continued. The vapor-heat treatment was authorized for tomatoes, bell peppers, and zuccini squash, in addition to papayas, as a condition for export to the mainland. It has been discovered that the period during which the fruit is held at the lethal temperature of 110° F. is the important factor in the effectiveness of this treatment, and that the supervised approach period may not be necessary.

The export of fresh pineapples has been made possible as the result of tests which show that fumigation with methyl bromide will remove the hazard due to chance infestation of these fruits. Treatment for 6 hours with 2 pounds of methyl bromide per 1,000 cubic feet is effective. Another fumigant showing promise against these flies is a 3 : 1 mixture of ethylene dichloride and carbon tetrachloride. Preliminary work has also been done on the use of gamma rays, accelerated electrons, and high-frequency radiation as means of treating infested commodities, but the results thus far with these methods have not been favorable.

The fumigation requirement for *Vanda* orchids was removed after a careful study of the biology of the fly on this host indicated that it cannot complete its development on that plant. Therefore, movement of these orchids presents no hazard to mainland agriculture.

Experiments on chemical control have two main objectives, the testing of insecticides as direct controls and the development of lures and repellents. Laboratory tests showed ethyl *p*-nitrophenyl thionobenzene phosphate (EPN), dieldrin, parathion, and DDT to be the most effective residual insecticides, but in field tests they did not give very satisfactory control in heavily infested plantings. Dieldrin, aldrin, chlordane, lindane, and a mixture of two nitroparaffins were all more toxic than DDT in aerosol fogs. However, no insecticide has been found to prevent flies from laying some eggs in the fruit.

The development of methyl eugenol as a lure for male fruit flies for use in traps will greatly increase the effectiveness of scouting operations in California. Methyl eugenol will attract male flies from more than half a mile against a wind of 10 miles per hour. In 4 months nearly 2 million flies were captured in 30 glass traps exposed in various situations on Oahu. In experiments in which this lure was used in combination with parathion in box traps, the percentage of males in the area declined from 45 to 0 after about 4 months.

Basic work on the control of this fruit fly in large areas has included operations in urban localities close to wild hosts of this fly and in gulches covered with wild host plants. Airplane applications of DDT sprays in some of the rugged guava-infested gulches have been moderately successful, and sprays applied in certain villages have reduced adult fly populations by 98 percent. These studies provide a foundation for large-scale experiments which are planned for a later time, perhaps on an entire island.

909586—50——2

Life-history studies show that 10 days are required for a male and 7 days for a female oriental fruit fly to become sexually mature after emerging as an adult. The fly has lived for a year on mountain slopes where freezing temperatures occasionally occur and where the climate is much the same as in many parts of the mainland. It has now been found in 128 kinds of fruit, many of which are also grown in California.

In experiments on migration, marked fruit flies have been recovered 20 miles from the point of release. This fly has also crossed an ocean strait 9 miles wide, can be carried on the outside of fast-moving vehicles, and will drift back and forth over large areas. These habits would greatly complicate quarantine and control measures in the event of a mainland infestation.

Tests on airplanes indicate that the adoption of automatic instead of hand disinsectization equipment should reduce the chances that hitchhiking flies might reach the mainland.

The search for natural enemies of the oriental fruit fly has been under way since 1948, conducted in part with funds authorized under the Research and Marketing Act. By July 1949 four species of parasites had been reared in the laboratory and released throughout the territory. In the next 10½ months about 70,000 adults of 36 species were reared from 162 shipments containing 767,000 fruit fly puparia collected in India, China, Formosa, Thailand, the Philippines, New Guinea, Australia, and various parts of Africa. Many of these species could not be propagated on the fruit flies in Hawaii, but six species have been successfully bred and liberated in the field. Three parasites are already established, and two of them show great promise as control agents.

Late in the year research on the physiology of this fruit fly was added to the other projects with a view to learning more about the reaction of the flies to lures, how insecticides kill, and the food requirements of the insect. Such information will undoubtedly aid in the development of control measures.

Efforts To Keep Citrus Blackfly From United States Intensified

The citrus blackfly is spreading in Mexico, and its northward advance is bringing it closer to large citrus-producing areas in the United States. To protect our citrus industry the Bureau has for several years been cooperating with the Mexican Government and growers in Mexico in a campaign to control the pest in that country.

Surveys to learn the distribution of the pest in Mexico were stepped up in October 1949, after additional funds were made available for this work. Since then intensive inspections have been conducted in the citrus-producing States of Tamaulipas, Nuevo Leon, and Sonora, and in Baja California. A single infested tree was found in the city of Matamoros, just across the Rio Grande from Brownsville, Tex. Nearly 300 infested dooryard plantings were discovered in Monterey, which is on a direct line of traffic to extensive citrus plantings in the Lower Rio Grande Valley. Light infestations were also found at Montemorelos and Hidalgo, also in Nuevo Leon. Prompt discovery of these infestations and prompt application of sprays apparently suppressed them, but only continued vigilance through both surveys and quarantines, followed by prompt eradication measures when nec-

essary, will prevent the insect from reaching citrus groves in the United States. The blackfly has not been found in Sonora north of Hermosillo, or in Baja California near the California or Arizona line.

Bureau workers have been experimenting with various insecticide treatments, and have developed several spray formulas which appear to be giving excellent results in suppressing infestations as well as good commercial control of the pest. The most satisfactory formula found thus far contains cube and an emulsive oil. DDT in xylene and kerosene is also effective under some conditions. Spray experiments in western Mexico in 1949 practically eliminated the blackfly at Hermosillo and from many of the infested properties in the Guaymos-Empalme area.

To aid in the surveys, traps are being developed which consist of yellow sticky panels about 4 by 10 inches. A single trap set out in a heavily infested area has caught nearly 22,000 adult blackflies in 6 days.

In a search for wild hosts of the citrus blackfly in San Luis Potosi, *Ardisia* and *Eugenia* trees and shrubs were found to be heavily infested, possibly serving as important reservoirs from which citrus groves became infested. Fortunately these plants do not occur in northern Mexico, where the spray experiments are being carried out.

Fumigation of crated limes with methyl bromide gave only 1 survivor out of nearly 125,000 blackflies, in experiments to find the best treatment of citrus fruit before it is shipped across the border to the United States. The limes were exposed for 2 hours to 2 pounds of methyl bromide per 1,000 cubic feet. The blackfly population was much greater than would occur in commerce.

More effective natural enemies of the citrus blackfly for use in Mexico have been found in India and Pakistan, and 25 consignments comprising 7 parasite species and 3 predators were forwarded to Mexico. One hundred and sixty-seven colonies, principally of *Prospaltella clyealis* Silv., were released at widely separated points in the infested area. Observations in western India, where the climate is similar to that of Mexico, indicate that the pest is adequately controlled by natural enemies, mainly *P. clypealis*. It is hoped that these parasites will be better adapted to the semiarid conditions of Mexico, and consequently more effective in control, than was *Eretmocerus serius* Silv., which was of Malayan origin.

Parathion Controls Purple Scale and Advances Maturity of Oranges in Florida

Parathion wettable-powder sprays gave good control of the purple scale and advanced the maturity of oranges, in experiments conducted in Florida in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering. Control of the purple scale with parathion was at least as good as that obtained with oil sprays. One application in June kept infestations below prespray levels for 7 or 8 months, and August applications were still effective after 5 or 6 months. The best results were obtained with sprays applied in both June and August.

Parathion is compatible with the wettable sulfur included in all sprays to control the citrus-rust mite, and it appears to be economically feasible to add it to the regular rust-mite sprays, if two applications

are needed in the same year. Parathion did not control either this mite or the citrus red mite.

Where parathion was used alone, coloring was advanced and solids reached marketable levels earlier than in unsprayed oranges. This effect of parathion on the quality of the fruit is of considerable interest to citrus growers, since it may help solve the problem of how to improve the quality of Hamlin oranges to permit marketing them earlier. The use of parathion against scale insects will also provide a means of avoiding retarded maturity of oranges, which is a problem following late applications of oil sprays. Special precautions must be used in handling parathion, as it is a dangerous poison.

Sterilization to Kill Mexican Fruit Fly Extends Citrus-Harvesting Season in Texas

The citrus groves in the Rio Grande Valley of Texas suffered from the severe freeze that occurred in January 1949. As a result, the fruit crop, although larger than had been expected, fell far short of those of previous years. Infestation of the Mexican fruit fly in the groves did not reach so high a peak as during a normal fruit-producing season, but enough properties were found infested to require considerable fruit sterilization. Grapefruit destined for shipment to areas that might become infested was treated by the vapor-heat method. This is a highly successful treatment and is a reliable safeguard against the dissemination of this pest through the shipment of fresh fruit. It is expected that, with the return of a normal crop year, harvesting and shipping of fruit from Texas groves can be carried on through the greater part of the year, since the fruit will have been sterilized before it is packed for shipment. The increasing use of this process is opening up a wider market each year and extending the harvesting season for Texas citrus fruit.

Spray Programs for Apple Insects Improved

In all apple sections DDT continued to give nearly perfect control of the codling moth when properly applied in the recommended number of applications, and was superior to other materials tested against that insect. However, because of the general use of DDT there is increasing concern over its accumulation in orchard soils. It has also been necessary to include other materials in the spray program to control insects and mites against which DDT is not effective. Many of them were not generally serious pests before DDT came into use. In recognition of these problems the work on pests of apple orchards was devoted largely to the development of improved spray programs.

In tests against the codling moth parathion compared favorably with DDT against light infestations in West Virginia, New York, and Washington, but was somewhat less effective against heavier infestations in Washington and Indiana. In Washington 2 pounds of 15-percent parathion wettable powder per 100 gallons was markedly more effective than 1 pound and as effective as 3 pounds. In Washington toxaphene also showed promise, and in New York TDE controlled a light infestation. In Indiana a laboratory mixture of DDT, TDE, and parathion was not only as effective against the codling moth as DDT at the recommended strength, but also held in check

other important orchard pests, such as the red-banded leaf roller, mites, and scale insects.

Additional evidence was obtained on the advantage of using small amounts of parathion with standard and reduced quantities of DDT, not only on codling-moth control but in restricting increases of other pests.

In Kentucky and Indiana large-scale tests in cooperation with growers indicated that dormant applications may soon be dispensed with for insect control in apple orchards. A mixture of DDT, parathion, and TDE, applied during the summer only, gave results against the codling moth, mites, scale insects, aphids, and the red-banded leaf roller that compared favorably with those effected by a dormant oil spray followed by a lead arsenate-DDT spray program during the summer.

In Washington three applications of sprays containing 15-percent parathion wettable powder gave excellent control of the woolly apple aphid, when 1 pound of this powder was used per 100 gallons. Inclusion of 1 pound of benzene hexachloride (12-percent gamma) in the first DDT cover spray prevented this aphid from becoming extremely numerous for the season, although a second application would have been desirable.

In Indiana inclusion of 1 pound of 25-percent parathion per 100 gallons in the calyx application of DDT almost cleaned up all aphids; however, the rosy apple aphid had already caused enough damage to suggest a need for earlier treatment when this species is present. TDE was found superior to lead arsenate when the red-banded leaf roller was present, and parathion also gave good control of this insect.

In Indiana 1 pound of 25-percent parathion per 100 gallons in the calyx and three DDT cover sprays or ¼ pound of 25-percent parathion in all cover sprays gave effective control of Forbes scale. However, parathion in the calyx and one cover spray gave only fair control.

Parathion has certain limitations for use in orchards despite the promising results it has given in insect and mite control, both as a supplement to and as a substitute for DDT in spray programs. It is an extremely dangerous material to handle, and special precautions must be observed by all who use it. Moreover, in the Northeastern States it is likely to injure the McIntosh and related varieties of apple. In Indiana it has caused a serious russeting on Golden Delicious apples and some russeting on Jonathans, but the fungicides used may have been a complicating factor. In New York a special safened parathion formulation also injured McIntosh fruit but less severely than the regular material.

Summer Sprays Evaluated for Mite Control

Mites were somewhat less destructive in deciduous-fruit orchards in 1949 than in the two or three previous years, but they continued to cause grave concern to commercial growers and they still represented the No. 1 problem to be solved in the development of improved spray schedules. Several species of mites are involved, and unfortunately few of the promising new insecticides have been found to be equally effective against all species. If conditions favor mite development, at least two summer applications of an acaricide will probably be required.

Parathion continues to be the outstanding acaricide, largely because it is highly toxic to all species of mites and has a residual effect. In field tests in Indiana, Washington, and West Virginia, it gave good control whether used in small amounts in several or all cover sprays to prevent development of infestation or in larger amounts in one or two applications against an established infestation. Although as little as ⅓ pound of a 15-percent wettable powder per 100 gallons gives good control, particularly if used in a series of applications, increasing evidence was obtained that about 1 pound per 100 gallons is the least amount that should be used to obtain the desired residual effect. Although the results obtained with parathion have been highly satisfactory, the hazard involved in its use indicates a need for a safer effective material.

Several other new materials appear to be extremely promising for mite control. 1,1-Bis(*p*-chlorophenyl)ethanol (DMC) was outstanding in West Virginia and promising in Indiana. In Washington it was as effective as parathion against the Pacific and clover mites but less effective against the European red mite.

Ethyl *p*-nitrophenyl thionobenzene phosphate (EPN), a compound closely related to parathion, appeared to be about as toxic when freshly applied and may have slightly greater residual value. In Indiana 3 ounces of a 27-percent EPN wettable powder per 100 gallons in all cover sprays kept mite populations at a low level throughout the season, and was slightly superior to 4 ounces of 25-percent parathion wettable powder per 100 gallons used in the same way. Mite populations became reestablished within 2 weeks on trees sprayed with parathion, whereas they remained at a low level for 3 weeks on trees sprayed with EPN. A laboratory-prepared formulation containing DDT, TDE, and parathion controlled mites about as well as did EPN when included in all cover sprays.

The most effective treatment against the clover mite on plums in Washington in July and August was 3 pounds of wettable sulfur per 100 gallons containing 1 percent of liquid lime-sulfur. A 34-percent sulfur dust and 1-percent summer-oil spray were about as effective, but a 2-percent parathion dust gave poor results. On peaches the wettable-sulfur spray containing liquid lime-sulfur and the 2-percent parathion dust gave good control of the two-spotted spider mite, but the 34-percent sulfur dust was ineffective.

Parathion Most Effective Against Pear Psylla

The pear psylla has continued to spread in the Pacific Northwest. It is now firmly established throughout the Yakima Valley in Washington and present in about three-fourths of the pear orchards in the Hood River area in Oregon.

In Washington the pear psylla was readily controlled with one summer application of ½ pound of 15-percent or ⅓ pound of 25-percent parathion wettable powder per 100 gallons. Parathion, despite its hazard to the operator, is now the standard insecticide for controlling the pear psylla during the summer in Washington and widely used in New York. The number of applications required varies with seasonal conditions affecting the development of the insect.

In New York parathion was found to be the most effective ovicide for controlling the pear psylla when pear buds are in the green-tip

stage. Sprays made with ¼ pound of a 25-percent parathion wettable powder per 100 gallons killed 89 percent of the eggs present, and those made with ½ pound or larger quantities gave practically complete kill. Sprays containing 0.5 percent of the ammonium salt of dinitroamylphenol or dinitrobutylphenol killed about 90 to 95 percent of the eggs present and were more effective than those containing the sodium salt of dinitroorthocresol. Sprays containing 2 percent of oil were of little value against the eggs.

In Washington toxaphene was nearly as effective as parathion in summer applications, but it was not dependable under New York conditions. In New York good control was obtained with cube plus oil and with nicotine sulfate plus lime. In preliminary tests two nitroparaffin compounds and aldrin gave results that justify further trial.

Control of Cherry Leaf Miner Improved

For control of the cherry leaf miner, benzene hexachloride and chlordane were found to be superior to the previously recommended combination spray containing an aliphatic thiocyanate, powdered cube, and summer oil. Two applications of benzene hexachloride, when the buds were pink and at petal fall, materially reduced the adult population and curtailed egg laying. A single application of either benzene hexachloride or chlordane when the larvae were small also gave a high degree of control. This pest of English Morello cherries in New York State may damage 30 to 50 percent of the foliage so that it can no longer function or drops prematurely.

Progress Made in Hall Scale Eradication

In the Hall scale eradication work at Chico, Calif., nearly 15,000 trees were fumigated with hydrogen cyanide during the winter of 1949–50. On properties having more than 9,000 host trees this was the third fumigation since the last living Hall scale was found. These trees will now be dropped from the treatment schedule, but they will be carefully inspected for at least 3 years to make certain that eradication of the scale has been achieved. On two of the properties more than 1,000 trees in areas adjoining the original infestations were fumigated as a precautionary measure. All trees on properties remaining on the treatment schedule at the end of the 1948–49 fumigation season received two applications of an oil spray during the summer of 1949, to prevent the build-up and possible spread of scales that might have survived previous treatments.

Several new Hall scale infestations were found in the Chico area during the spring of 1950. However, these findings do not add materially to the infested area, the total number of trees (about 2,000) is comparatively small, and the infested properties are not close to extensive commercial plantings. Surveys at distant points that had previously received trees or propagating wood from the infested area were continued, but no Hall scale was found.

Toxaphene Shows Promise Against Pecan Weevil

Good control of the pecan weevil was obtained in Georgia with two applications of a spray containing 6 pounds of 25-percent toxaphene

wettable powder in 100 gallons of water. The spray was applied on August 11, when the first adult weevils were found on the trees, and again on August 23. If further work substantiates these results, pecan growers will have another material for controlling this serious pest of pecans which may be considerably less expensive than the DDT treatment now in use.

Twig Girdler on Pecan Controlled With DDT or Parathion

The twig girdler, an insect for which there have been no satisfactory insecticides, frequently causes severe damage in pecan orchards. In tests conducted in cooperation with the Florida Agricultural Experiment Station, excellent control of this insect was obtained with parathion or DDT sprays applied at 2-week intervals through the season for control of the hickory shuckworm. The applications made in August and September appeared to be responsible for preventing the usual girdler injury, but further experimental work is needed before the most practical schedules and spray concentrations for grower use can be determined.

FOREST INSECTS

Annual Forest-Pest Surveys Now a Fact

The program of annual surveys authorized by the Forest Pest Control Act of 1947 was initiated after funds were made available on July 1, 1949. By these surveys it is hoped to detect incipient outbreaks of forest insects so that control measures can be applied before serious damage has been done. During the year technical personnel were selected for carrying out this program and headquarters established in different sections of the country, including New Haven, Conn.; Asheville, N. C.; Milwaukee, Wis.; Fort Collins, Colo.; Ogden, Utah; Coeur d'Alene, Idaho; Portland, Oreg.; and Berkeley, Calif.

Personnel at these stations have been acquainting other agencies, such as the Forest Service, the National Park Service, State organizations, and private timberland owners, with the provisions of the act and seeking their cooperation in surveying their respective territories for forest-pest conditions. A considerable amount of actual pest-survey work was also accomplished during the year. Forested areas never before surveyed for this purpose were examined, some from the ground and some by air. Before these activities can be made fully effective, much remains to be done through the participation of still other agencies and individuals and in the development of survey techniques for the vast forested areas in this country. Nevertheless, the work already done in the short period since the program became active offers assurance of its value in the prompt detection of injurious pests in our forests.

DDT Sprays Effective Against Spruce Budworm Outbreak in Oregon

The spruce budworm continued to spread in Oregon, and by 1949 about 2¼ million acres of forests were infested. Because of the excellent control obtained in 1948 from aerial spraying of test plots with DDT, 267,000 acres of infested high-value Douglas-fir were sprayed in 1949. One pound of DDT in 1 gallon of fuel oil was used per acre.

This spray operation was highly successful, the infestation being reduced by 97 percent, at a cost of only $1.20 per acre. However, much of the infested area was left untouched. This was a cooperative project conducted by private timberland owners, State agencies, and the Federal Government. The continued good results convinced all interested parties of the soundness of the program, and recommendations were made that an additional area of approximately 900,000 acres be sprayed in 1950.

Cause of Ips Beetle Outbreaks Better Understood

Recent investigations have shed more light on the cause of outbreaks of *Ips* bark beetles in California pine stands. Ecological studies had shown that these outbreaks are associated with climatic conditions, but this discovery did not explain their occurrence in one stand and not in another within areas of similar climatic influences. This year it was found that the age and size of the trees that are cut, timber type, and elevation also are important factors affecting *Ips* damage in stands remaining after timber has been cut. The most important factor is the size of the trees that are cut.

Ips bark beetles breed in the slash left from logging operations. The greater the quantity of this material, the greater will be the population of the *Ips* that develops. The unmerchantable top of a 16-inch tree contains practically as much breeding material as does that of a 40-inch tree. For every 1,000 board feet of lumber cut from trees 16 inches in diameter, approximately 800 square feet of bark area suitable for *Ips* breeding is left, whereas when the same amount of lumber is cut from 40-inch trees only about 30 square feet of bark area is left. The possibilities of *Ips* outbreaks are therefore enormously greater in reserve stands following cutting operations in trees of small diameter. This goes far toward explaining the occurrence of serious *Ips* outbreaks following timber cutting in second-growth pine and only light infestations after similar cutting in virgin timber.

Sanitation-Salvage Logging Continues To Pay Off for Bark Beetle Control

Bark beetle control by the systematic removal from the stand of trees in poor health was reported last year to have proved successful beyond expectations. Its value has been further confirmed this year. Recent figures show that this type of control may be accomplished at a net profit through the sale of logs from the trees that are removed. One of the largest lumber companies in the West has instituted this practice as an integral part of its annual operations and has already made new cuttings on 185,000 acres of its lands. This is the first record of a timber-producing company's adoption of sanitation-salvage logging as a part of its plan of management for the sustained production and yield of saw logs.

Costs of Bark Beetle Control Reduced

Bark beetles in pine, Douglas-fir, and Engelmann spruce trees can now be destroyed much more economically than heretofore. In the past it has been necessary to fell these trees before spraying them with

909586—50——3

insecticides, or decking and burning them, but improved methods have made it possible to spray them with bark-penetrating insecticides while they are still standing.

Work this year has demonstrated the practicability of controlling *Ips* beetles by piling the slash from cutting and logging operations and spraying it with DDT in Diesel oil.

The possibility of further reducing the cost of bark beetle control was indicated this year, when it was shown that emulsions of ethylene dibromide are effective against the Black Hills beetle. Work is in progress to determine its value against other bark beetles.

Benzene Hexachloride Effective Against Bark Beetles and Wood Borers in Stored Pulpwood

The perennial problem of bark beetles and wood borers attacking stored pulpwood in the Southern States may soon be solved. In tests conducted this year the application of benzene hexachloride to this material with a power sprayer soon after it was cut prevented attack by these insects for 3 months. Studies are continuing in an effort to determine the most satisfactory formulations of this insecticide, the length of time it remains effective, and how it should be applied to provide maximum benefit.

Fuel Oil Kills Lyctus Powder-Post Beetles in Small-Dimension Stock

Tests established early in 1948 to determine the effectiveness of various insecticide formulations in controlling lyctus powder-post beetles in small dimension stock were completed. While practically all the formulations tested were effective against these insects, the significant finding was that No. 2 fuel oil alone gave complete control following a 3-minute dip of the stock in this material. Hence it appears that the addition of chemicals to this oil is useless from the standpoint of remedy alone. However, if it is desired to prevent re-infestation of such small-dimension stock, a chemical such as benzene hexachloride should be added.

Food of Birds and Fish Little Affected by Woodland Spraying With DDT

Spraying woodlands by airplane has proved its effectiveness for the control of various destructive forest insects. An important consideration in connection with such measures is the effect on fish and birds within the treated area, not only directly, but also indirectly through its effect on their food, including insects.

A 52,000-acre woodland area in Pennsylvania was sprayed in 1948 by airplane to control the gypsy moth. Within this area are two watersheds supplying fresh-water streams. A study of the repopulation of stream-bottom insects, which are important fish food, following the application of 1 pound of DDT in a gallon of oil per acre was completed this year. There was a sharp decline in the numbers of these insects immediately after the spray was applied. In general, the adverse effect was greater downstream, although at certain points upstream it was also severe. The different species varied greatly in their susceptibility to the contaminated water; some were almost elimi-

nated, whereas others seemed hardly affected at all. However, within 2 to 3 months the affected species in general had become reestablished. Thereafter their numbers continued to increase until a year later they equaled or exceeded the population in existence before the area was sprayed.

For five successive years a 117-acre woodland tract on the Patuxent Research Refuge in Maryland has been sprayed with a DDT-oil solution. This spray was applied by airplane at the rate of 2 pounds of DDT per acre. After each spraying insects rained down from the forest canopy for about 24 hours. Despite this wholesale destruction of insect life, follow-up studies indicate that insect repopulation has taken place rapidly. The temporary near-elimination of insect life caused by this spray has not seriously affected the bird population in the stand, ornithologists having been unable to record any measurable differences between the sprayed and nearby unsprayed areas.

These studies were made in cooperation with the Fish and Wildlife Service of the Department of the Interior.

Poisoning Soil With DDT Prevents Termites From Attacking Woodwork

Termites can be controlled more easily and cheaply if efforts are directed toward prevention of attack rather than their eradication once they have become established in wooden structures. Many chemicals have been tested through the years to find the cheapest, safest, and most effective one for use in treating the soil around structures, through which these insects often travel before making contact with the wood. A solution containing 5 percent of DDT in No. 2 fuel oil mixed with soil at the rate of 1 quart per cubic foot has given complete protection for 5 years to wood in contact with the treated soil. Research is being continued to find out how much longer the treatment will be effective, and also whether DDT is better than other chemicals now in use.

Mist-Blower Performance in Spraying High Trees

In a study of the performance of mist blowers in spraying high trees, it was found that the distance reached is directly related to the delivery capacity of the blower. The greatest deposit of insecticide at the highest elevation is obtained when the blower is operated in light winds with the machine stationary and the nozzle pointed to the top of the tree a short time before the spray is released. The most efficient particle size to use depends on the spread of the tree and the spray velocity at the height required. With a blower having a capacity of 10,000 cubic feet of air per minute, spray particles having a mass median diameter of 100 microns (about 0.004 inch) are best for treating a tree 80 feet high. The particle size can be regulated by varying the manner of introducing the liquid into the air stream.

Gypsy Moths

Trapping and spraying programs expanded

The largest trapping and spray operations ever attempted on the gypsy moth program were carried out during the year with the coop-

eration of State, county, and municipal agencies. All the New England States, Pennsylvania, New York, and New Jersey furnished aid in the form of personnel, equipment, and materials. This pattern followed very closely the one of former years, but with increased funds provided in Massachusetts by State, county, and municipal governments.

Gypsy moth populations showed a decided increase in the summer of 1949. This moth caused defoliation on 78,673 acres as compared with 32,467 acres in 1948. Except for a very small area in four New Hampshire towns, all this defoliation occurred in southeastern Massachusetts. This increase indicates that gypsy moth populations are on an upward trend following several years of relatively light infestation. The absence of defoliation in the other areas points to the effectiveness of the control program, especially in New York and Pennsylvania. Weather conditions during the hatching and larval development periods were favorable.

Nearly 7 million acres in Pennsylvania, New Jersey, New York, Massachusetts, Vermont, and Connecticut were surveyed with the aid of 17,047 traps containing attractant. The cost of this work was approximately 1 cent per acre. No male gypsy moths were caught in about 2 million acres surveyed in Pennsylvania or in the areas surveyed in New Jersey. The Quakertown, Pa., infestation, which was discovered in the fall of 1948 and sprayed the following spring, was thoroughly trapped with negative results. The information obtained from catches of the male moths in the other States was used in preparing plans for subsequent scouting and spraying. Nearly 2 million acres were surveyed manually, and results from this and the trap survey continue to indicate that the western limits of the infested area have been determined.

In the spring of 1950 nearly 583,000 acres were sprayed by airplane with DDT in Federal-State cooperative programs in New York and Massachusetts, at a cost not exceeding $1 per acre. In addition 17,200 acres were sprayed with mist blowers, hydraulic sprayers, and knapsack sprayers. Some of the ground spraying was done in Pennsylvania, Connecticut, and Vermont. The highest dosage used was 1 gallon per acre of an oil solution containing 12 percent of DDT. After the gypsy moth eggs hatched, the strength was reduced to 9 or 6 percent according to the density of the infestation.

The Bureau used one of its C–47 planes and several biplanes. In New York two State-owned Stearman biplanes were used, and in Plymouth County, Mass., in addition to Bureau aircraft, several types of commercial planes including two C–46's and helicopters were operated on contract. Nine ground mist blowers were operated, six of which are federally owned, two belong to the New York Conservation Department, and one to the Pennsylvania Department of Agriculture. The mist blowers were used for spraying along highways and roads, junk yards, nurseries, dumps, and recreational and residential areas, and hydraulic sprayers for spraying around large trout hatcheries in southeastern Massachusetts, where it was important to control the drift of the spray. Frequent observations during the spray operations indicated excellent results, and all the areas sprayed were included in the trap surveys to be begun in July 1950.

New procedures make quarantine enforcement more efficient

In enforcement of the gypsy moth quarantine increased reliance was placed on field inspections in woodland areas to determine their freedom from infestation, on insecticide applications in nurseries and quarries, and on commercial practices that destroy the moths, as substitutes for time-consuming visual inspections of products submitted for certification.

Extensive pulpwood lots in sparsely infested sections were scouted for freedom from infestation before the wood to be certified was cut. Officials of Quincy, Mass., practically eliminated infestation on regulated quarry products by spraying quarry areas in the city. Nurserymen applied DDT sprays to 217 plots and border zones in 1949 while the moths were in the larval stage and again before eggs hatched in 1950. Other plots were similarly sprayed during the 1950 larval period. All plants in these sprayed areas qualified for certification. Some growers made additional treatments to destroy both gypsy moths and Japanese beetles to make the stock eligible for joint certification under the quarantines for both pests. Such cooperative efforts increased the efficiency of quarantine enforcement at no greater cost to the Federal Government and allowed speedy movement of the certified products by shippers.

Conditional shipments of uninspected products to paper mills and other plants in nonregulated territory, where the products were so handled as to destroy any incidental infestation, were reduced in 1950. This change was necessary because inspectors were not available. In some instances producers and shippers were inconvenienced and their costs increased.

Certificates of safe movement from quarantined areas were issued on the following products produced in New York and New England: 167,000,000 board feet of lumber, 97,000 cords of pulpwood, 34,400,000 nursery and field-grown plants, 344,300 Christmas trees, and 678,000 miscellaneous lots of quarry products. Over 36,600,000 board feet of lumber and 8,000,000 squares of shingles were certified for safe movement to Canada from nonregulated parts of New England. The value of products so moved was placed at $48,800,000.

To conserve time and equipment in New York and New England, the same inspectors examined products for both Japanese beetles and gypsy moths. Equipment used for fumigating Christmas trees was also used in Japanese beetle work during the summer. State inspectors gave much assistance during peak work periods.

Inspectors patrolled roadways leading from regulated to nonregulated areas. They intercepted a small number of illegal shipments, and discouraged willful attempts to violate the gypsy moth quarantine. In western Vermont an information and inspection station was operated where truckers could obtain specific information about the gypsy moth quarantine and could have their loads of regulated products properly certified.

The effectiveness of gypsy moth quarantine and control work made it unnecessary to extend the boundaries of the regulated areas during the year.

TRUCK CROP AND GARDEN INSECTS

Improved Aerosol for Greenhouse Pests

An aerosol containing 5 percent of tetraethyl dithiopyrophosphate with methyl chloride as the propellent gas has proved very effective against various greenhouse pests and relatively safe for use on tender plants. In experiments conducted in the Bureau's greenhouses at Beltsville, Md., and in commercial greenhouses, this aerosol was found to be more toxic than aerosols containing the same concentration of hexaethyl tetraphosphate or tetraethyl pyrophosphate to the resistant two-spotted spider mite on roses, mealybugs on various crops, and whiteflies on vegetables. It has also proved noninjurious to a large number of greenhouse crops, including chrysanthemums and seedling tomatoes of the varieties most susceptible to injury by aerosols containing tetraethyl pyrophosphate.

Tetraethyl dithiopyrophosphate, like other phosphate insecticides, is highly poisonous. Although in these experiments the material dissipated rapidly, data on cumulative residues are incomplete. It is advisable, therefore, not to use this aerosol on greenhouse-grown tomatoes or cucumbers when in bearing or on leafy vegetables at any time.

Wild Hosts of Beet Leafhoppers Sprayed To Protect Beans From Curly Top

Progress was made during the year in experiments to protect the seed crop of green beans from curly-top disease by controlling its carrier, the beet leafhopper. These leafhoppers feed and multiply on weeds in uncultivated areas in the spring, and as the weedy plants die the mature leafhoppers move to bean fields. In May and June 1949 approximately 2,600 acres of heavily infested wild mustard close to the bean-growing area in southern Idaho were sprayed with a pyrethrum-oil emulsion. The sprays were applied with turbine blowers, equipped with USDA broadcast nozzles, mounted on high-powered trucks. Examination after the spraying showed a reduction in leafhopper numbers of 91 percent below the prespray count of 44 per square foot, which is equivalent to nearly 2 million leafhoppers per acre. In another experiment various insecticides were applied to wild mustard by airplane early in June and again in August. Pyrethrum sprays reduced leafhopper populations by 71 percent, parathion by 90, and DDT by 98 percent.

When 92 fields of seed beans in southern Idaho were examined in July, 12 percent of the plants were infected with curly top, whereas in 40 fields of Great Northern beans, a curly-top resistant variety, less than 5 percent were affected. It was not possible to separate a nontreated check area for comparison. However, during the previous 12-year period curly-top infection of seed beans in this area was as high as 44 percent and of Great Northern beans 17 percent.

These experiments were conducted in cooperation with the Idaho Agricultural Experiment Station, with funds authorized under the Research and Marketing Act.

Cantaloup Plants in Cotyledon Stage Most Susceptible to Curly Top

The curly-top virus, known to be carried by beet leafhoppers, has been suspected as being responsible for the dying of young cantaloup plants in the Southwest, although the plants show no recognizable symptoms of the disease. To learn more about the importance of curly top in the production of cantaloups in this area, experiments were conducted at Phoenix, Ariz., in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering. Beet leafhoppers known to be curly-top infective were encaged on cantaloup plants, some in the cotyledon and others in the two-leaf stage. When each plant was exposed to 6 to 15 leafhoppers for 1 week, all plants in the cotyledon stage were either killed or severely stunted but those in the two-leaf stage were only slightly retarded in growth and none were killed. When one infective leafhopper was allowed to feed for 24 hours on each of several plants in the cotyledon stage, some of the plants were drastically stunted but others did not seem to be affected. None of the usual symptoms of curly top developed in any of these plants.

These experiments indicate that cantaloup plants are most susceptible to the curly-top virus when they are in the cotyledon stage and that they develop some resistance to the disease before they reach the two-leaf stage. Studies are being made to develop methods of protecting the plants from beet leafhoppers during the susceptible stage.

Spraying and Fumigation Compared for Control of Stored-Tobacco Insects

In large-scale tests in Virginia, North Carolina, and South Carolina 36 tobacco warehouses were sprayed weekly with pyrethrum in oil and 55 were given periodic fumigation with hydrogen cyanide from May to October 1949. The spray was much more effective and substantially cheaper than fumigation in controlling the tobacco moth, but not effective against the cigarette beetle, and fumigation with hydrogen cyanide was necessary to control a heavy infestation of the latter insect. The pyrethrum-oil spray appears to be the most effective agent yet found for control of the tobacco moth. These tests were made in cooperation with the Production and Marketing Administration.

Light Weight Mist Blower Designed for Use on Vegetable Crops

A light-weight mist blower for applying concentrated sprays to vegetable crops has been developed in cooperation with the Wisconsin Agricultural Experiment Station. The air blast in this blower is generated by a 30-inch radial fan driven by a 22-horsepower gasoline engine designed to deliver approximately 3,500 cubic feet of air at a velocity of 5,500 feet per minute. The air is directed through a large sheet-metal duct and discharged through four galvanized-metal tubes spaced along the duct. The tubes have fishtail outlets, which are directed to the rear and downward at a 45-degree angle, distributing

the spray uniformly over swaths up to 20 feet in width. In the operation of this blower the concentrated spray mixture is drawn from a 10-gallon tank at rates ranging from 5 to 15 gallons per acre.

This mist blower was used in field tests against the pea aphid, cabbage caterpillars, the potato leafhopper and the potato flea beetle, the onion thrips, and the six-spotted leafhopper on carrots. Many insecticide formulations were applied, including those containing DDT, parathion, and tetraethyl pyrophosphate. The control was generally as good as with the conventional high-gallonage sprayers. This equipment can be easily maneuvered through fields of vegetables, causes less mechanical damage to the plants than the heavier and more cumbersome conventional sprayers, and requires a minimum of water hauling for its operation. Further tests with the experimental unit must be made, however, before it can be considered for recommendation and adoption for general use.

Some Crops Not Injured by DDT and Toxaphene in Soil

The effect of insecticides in the soil on the yield of crops grown therein was studied at Presque Isle, Maine, in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering and the Maine Agricultural Experiment Station. For two consecutive years DDT and toxaphene were applied, singly and together, to soil in which potatoes, oats, or barley was grown. Total applications of 80 pounds of DDT and 47 pounds of toxaphene per acre had no adverse effect on the yield of potatoes grown in 1949, and 60 pounds of DDT and 32 pounds of toxaphene per acre applied to the soil in 1948 caused no reduction in the yield of oats or barley grown in 1949. Neither of these materials was found in samples of potato tubers grown in the treated plots.

Sweetpotato Weevil

Dusting of stored sweetpotatoes extends marketing period

A new treatment for control of sweetpotato weevils which permits shipment of sweetpotatoes over a greatly extended marketing period has been developed in cooperation with the Louisiana Department of Agriculture and Immigration. Early in the fall of 1949 it was shown that washing would remove DDT dusts from sweetpotatoes to a level not hazardous to consumers. Previous tests had shown that these dusts applied to stored sweetpotatoes kill all emerging weevils and prevent populations from building up. On the basis of this information, the Louisiana quarantine regulations were amended to extend indefinitely the previous April 1 clean-up date provided stocks in storage are dusted before March 1. This clean-up date, enforced because of the rapid increase thereafter in weevil populations which infested nearby plantings, often caused a deterioration of the market late in March and thousands of bushels of sweetpotatoes had to be destroyed.

Under the amended regulations 1,572,000 bushels of sweetpotatoes were dusted and marketed during the spring months of 1950, when prices are normally the strongest. An inexpensive duster has been developed by Bureau workers, which dusts sweetpotatoes one at a

time at the rate of about 600 crates per hour, using only one-twentieth of a pound of dust per crate.

In tests conducted in cooperation with the Louisiana Agricultural Experiment Station, methoxychlor was also found to show promise for this purpose. Dusts containing 10 and 50 percent of methoxychlor applied to the inside of cages in July 1949 killed all the adult weevils introduced at 30-day intervals thereafter until the end of April 1950. The 10-percent methoxychlor dust killed the weevils more slowly than 50-percent methoxychlor or 10-percent DDT and therefore may afford less protection against reinfestation.

Educational campaign aids weevil control

More than 10,000 farms in the South have been freed from sweetpotato weevils since the program to eradicate this pest was begun in 1937. This program, which is conducted in cooperation with the States, includes clean-up of seedbeds, fields, and storages, establishment of nonplanting zones, and enforcement of quarantines. In 1949 the weevil was eliminated from more than 1,600 farms, three-fifths of which were in 10 Louisiana parishes and the remainder in 23 counties of Alabama, Florida, Georgia, Mississippi, South Carolina, and Texas.

An educational campaign in Louisiana has been largely responsible for the accomplishments in that State. With the assistance of this Bureau, the Extension Service, and State agencies, organizations of sweetpotato growers in the different parishes have been using various means of informing the public of the importance of eradicating this weevil and how it may be done. Such information was disseminated through meetings held for the purpose, and demonstrations of field and storage clean-up and of dusting sweetpotatoes were given in many communities. Mimeographed sheets describing the program and giving instructions on dusting sweetpotatoes were distributed.

The educational program is being extended to other States, particularly Georgia, where infestations were found in 11 additional counties between October 1949 and May 1950, and to Texas, where 1 additional county has recently been found infested. Most of these infestations are traceable to infested planting stock moved into weevil-free areas contrary to quarantine regulations. Education of the growers as to the losses that may result from sweetpotato weevil infestations appears to be the most effective means of stopping such practices.

A county-wide nonplanting zone was established with grower approval in Houston County, Tex., in 1949 to starve out the weevils. This plan has been found so effective and has met with such general approval that similar measures have recently been taken in adjoining Trinity County.

New Insecticides Tested Against Various Truck-Crop and Garden Insects

Cabbage caterpillars

A report that evaluates 23 insecticides for the control of various species of caterpillars occurring on cabbage and other cole crops was issued during the year as E–787 in the Bureau's processed series. This report is based on field-plot tests conducted for 7 years at Charles-

ton, S. C., in cooperation with the South Carolina Agricultural Experiment Station.

DDT was the most effective material against mixed infestations. Sprays were at least as effective as dusts applied at the same dosage. For ordinary dusts prepared from ground DDT, 3 percent was usually sufficient when applied every 10 to 14 days, but 5 percent was sometimes required in fall plantings to control some species. However, when prepared from a DDT solution or from ground DDT plus 2 percent of di- and tri-methyl naphthalenes, 1-percent dusts were just as effective. DDT was used on cabbage, collards, and broccoli in various stages of growth without plant injury. Its use on cabbage at any time during the preheading stage of growth greatly reduced and sometimes eliminated the need for further control measures. An application just before the plants began to head was found to be an excellent preventive measure, but no further applications should be made lest DDT residues occur on the marketed cabbage.

Benzene hexachloride was about as toxic as DDT to all the important caterpillars except the cabbage looper, when used in equal dosages of the active ingredient, but its effect was not so lasting. Toxaphene and TDE dusts containing 3 and 5 percent of the toxicant were approximately as effective as similar DDT dusts except that toxaphene was not quite so toxic to the imported cabbageworm. A 1-percent parathion dust compared favorably with 3- and 5-percent DDT dusts. At the strengths used, chlordane, methoxychlor, cryolite, sodium fluosilicate, and basic copper arsenate were generally inferior to DDT. Sodium fluosilicate dusts of 50 and 75 percent strength were quite toxic, but had inferior dusting qualities and caused more or less plant injury.

Materials that proved fairly toxic to one or more species of caterpillars were fixed nicotine, sabadilla, and ryania dusts and a strong nicotine-soap spray. Scorodite (hydrous ferric arsenate) was toxic to the cabbage looper and the imported cabbageworm. Hellebore (domestic), 2-chlorofluorene, phenothiazine, potassium fluosilicate, phenoxathiin, and xanthone were relatively nontoxic.

Aphids on potatoes

The spread of leafroll on potato can be reduced by a seasonal program of insecticide applications directed against the aphid vectors of the disease, principally the green peach aphid, according to studies conducted in the Yakima Valley of Washington, in cooperation with the Washington Agricultural Experiment Station. A dust containing DDT and sulfur gave the best results, apparently because of its greater residual toxicity as compared with dusts containing parathion. However, it will be necessary to supplement an insecticide program by using planting stock of potatoes practically free of the disease, by practicing crop rotations that will insure the destruction of volunteer potato plants, by providing as much space as possible between potato fields, and by practicing farm sanitation and related measures to destroy weed host plants of the aphids.

Experiments in Maine showed no significant differences in aphid control or yield of potatoes between dusts containing 5 percent of DDT, dust mixtures containing 2 percent of DDT plus 2 percent of oil or 1 percent of DDT plus 4 percent of oil, or sprays containing 0.5 pound of DDT or 0.15 or 0.075 pound of parathion in 100 gallons of

water. Mechanical and impregnated mixtures of DDT and oil were equally effective.

Narcissus bulb fly

Moderate control of the narcissus bulb fly was obtained with sprays and dusts containing DDT, lindane, parathion, toxaphane, chlordane, TDE, methoxychlor, and aldrin, in small-scale experiments on Long Island, N. Y., in cooperation with State agencies and the Bureau of Plant Industry, Soils, and Agricultural Engineering. In Washington State drenches containing toxaphene or benzene hexachloride gave some control of this insect, but the latter material retarded the blooming period. Parathion and DDT drenches were ineffective.

Pea weevil

Dusts containing 5 percent of methoxychlor, chlordane, toxaphene, aldrin, or dieldrin, or 1 percent of parathion were as effective against the pea weevil as a 5-percent DDT dust, in experiments conducted at Moscow, Idaho, in cooperation with the Idaho Agricultural Experiment Station. Ryania, piperonyl cyclonene, low concentrations of rotenone plus piperonyl cyclonene, and an organic thiocyanate were definitely inferior. When all factors are considered, methoxychlor seems to be the most promising insecticide for use as a substitute for DDT.

Pickleworm and melonworm

Lindane, parathion, and a refined grade of DDT were found to be more effective against the pickleworm and melonworm on cucumbers than any insecticides previously tested against these pests. Of the insecticides considered less harmful to warm-blooded animals, pyrethrum and sabadilla were the most toxic to both insects, but did not provide an adequate control of either species. Rotenone, methoxychlor, aldrin, ryania, and tetraisopropyl pyrophosphate were relatively ineffective. The use of cryolite, DDT, or parathion during the fruiting stage of the cucumbers may incur a harmful residue hazard, and the use of lindane at that time may give cucumbers an objectionable odor and taste. These experiments at Charleston, S. C., were conducted in cooperation with the South Carolina Agricultural Experiment Station.

Seed-corn maggot on beans

Chlordane and aldrin showed promise for control of the seed-corn maggot as a pest of sprouting beans in southern California. These insecticides were applied as sprays to the bean seeds and the surrounding soil at planting time, by means of a specially designed device attached to the rear of the bean-planter boot. Coating the bean seeds with chlordane, aldrin, parathion, DDT, or lindane, with or without a sticker, was also effective against the seed-corn maggot, but in some cases reduced the stand of plants.

Tomato fruitworm in California

DDT and TDE were found to be equally effective against the tomato fruitworm in southern California. Excellent control was also obtained with dusts containing aldrin or chlordane mixed with DDT.

Dieldrin gave satisfactory control in limited tests. Less effective were dusts containing aldrin, chlordane, toxaphene, methoxychlor, benzene hexachloride, lindane, the fluorine analog of DDT, two dinitro compounds, ryania, or parathion. Excellent control of this fruitworm was obtained with concentrated sprays containing DDT and good to excellent control with concentrated sprays containing toxaphene.

NEMATODES INFESTING POTATOES

Golden Nematode

Surveys disclose no infestation outside of Long Island

Surveys to determine the presence of the golden nematode in potato fields were undertaken cooperatively with 43 States, including for the first time those in the Northwest and Southwest. In some States they were made in connection with similar surveys for the potato rot nematode. Outside of Long Island, N. Y., where the only known golden nematode infestations in the United States occur, 69,015 soil samples, representative of plantings on 593,736 acres, were collected at sites where white potatoes are concentrated, as well as in potato and tomato fields. Laboratory processing of these samples failed to disclose the presence of this nematode.

In intensive surveys on Long Island 60,400 soil samples were collected from 48,037 acres in Nassau and Suffolk Counties. Examination confirmed infestations for the first time on 26 additional properties. With the exception of 5 properties in western Suffolk County, the lands involved are within the previously known infested areas in Nassau County. By June 30, 1950, infestations had been confirmed on more than 9,000 acres. About 3,000 of those acres have been diverted into real estate and industrial developments; therefore, confirmed infested lands subject to further cultivation now approximate 6,000 acres. Infestations were also uncovered on 39 establishments engaged in the retail sale of nursery stock and plants in Nassau and Queens Counties.

Federal-State cooperative measures to prevent spread

During the 1949 crop year growers on Long Island withheld 2,611 acres of cultivatable infested lands from potato and tomato production under the Federal-State compensation program, as authorized in the Golden Nematode Act passed by the 80th Congress and previous legislation passed by the New York State Legislature. Federal payments were limited to involved lands owned and operated by growers. The State of New York paid an equal share of compensation on such lands and assumed all responsibility for compensation on rented lands.

Assistance rendered to the State of New York in the enforcement of its quarantine regulations included supervising the handling of more than 200,000 bushels of white potatoes and the movement under prescribed safeguards of about 268,000 cubic yards of topsoil, and also tomato seedlings, root crops, nursery stock, plants, and other products capable of carrying the golden nematode. Regulated commodities so handled had an estimated value in excess of $1,000,000.

Cooperation was continued with the Bureau of Plant Industry, Soils, and Agricultural Engineering and the New York State College

of Agriculture in the conduct of experiments relating to golden nematode control methods, treatment procedures, and equipment development. Chemical control measures were applied on a heavily infested isolated field in Suffolk County and on infested establishments engaged in the sale of nursery stock and plants.

A mechanical soil washer was devised for processing soil samples to be examined for presence of the golden nematode and is being utilized in the conduct of surveys with a resultant savings in operational costs and improvement in efficacy.

Nematodes from abroad cause serious quarantine problem

The golden nematode presents one of the most complex foreign plant quarantine problems ever to confront the Bureau. Living cysts of this minute but destructive pest of potatoes and tomatoes were intercepted 87 times during the year, at 14 ports of entry, on the Atlantic, Pacific, and Gulf coasts as well as at the inland port of Chicago. The problem was made more difficult because the cysts were being found in soil associated with other than host material. Viable cysts were taken in soil associated with 34 kinds of plants and plant products arriving in mail, baggage, cargo, and ships' stores. Contaminated material included large shipments of lily-of-the-valley pips from Germany, a wide variety of root crops and vegetables in ships' stores, plants in cargo and baggage, shamrocks in the mails, tulip bulbs in cargo, and even screenings from oat straw used as packing for china. One 1½-pound sample of soil taken from beets in ships' stores from England contained an estimated 2,000 cysts. This nematode was also taken in soil with products from Ireland, Scotland, Wales, Netherlands, France, Poland, Denmark, and Sweden. It is also reported to occur in Belgium, which exports large quantities of plant-propagating material to the United States.

In the course of the extensive analyses of soil samples from imported material, cysts of several other species of nematodes were found, some of which are not known to occur in the United States and appear to be of considerable economic importance. Because of these findings inspection procedures were materially strengthened, and the requirement that imported plant material be free from soil was rigidly enforced.

Northwestern States Resurveyed for Potato Rot Nematode

An additional survey for the potato rot nematode was made early in 1950, in cooperation with agencies in 10 northwestern States. Inspections were extended this year to potato-growing areas of Wyoming and western Nebraska, and to many areas, particularly in Idaho, in which inspections were not made in 1949.

Approximately 307,000 bushels of potatoes from 1,756 properties in 100 counties of the 10 States, and 396 specimen lots from potatoes grown by approximately 396 growers in 68 counties of 8 States, were submitted to nematologists who examined them for the presence of nematodes. None of these specimens were found to contain nematodes that were definitely determined as the potato rot nematode (*Ditylenchus destructor* Thorne); however, in potatoes collected in the Mt. Vernon area of the State of Washington, suspect specimens were found which must be studied further to determine their identity.

During 1949 Idaho State inspectors found the potato rot nematode on four additional farms within the previously known infested area at Aberdeen.

COTTON INSECTS

New Insecticides for Cotton Insects Discussed at Annual Conference

The development of new insecticides for the control of cotton insects has been progressing so rapidly in the last few years that entomologists concerned with this problem have been holding special conferences to pool the results of their experiments. By this means it is hoped to provide the insecticide industry, extension services, and cotton growers with up-to-date authentic information on effective new materials. Sixty-seven entomologists and associated technical workers from 12 States and the Bureau participated in the third annual conference of this kind, which was held at Jackson, Miss., in November 1949. From their experiments and experiences general statements were drawn up to guide State and local workers in making recommendations for cotton-insect control in 1950.

Boll Weevil Infestations at All-Time High as Tests With New Insecticides Are Continued

Boll weevil infestations during 1949 averaged higher than in any year since 1927. In Arkansas and North Carolina the estimated reduction in yield caused by the weevils was the greatest ever recorded. In several southeastern States damage was greater than in any year since 1923. As a result of favorable conditions for weevil development and spread, the insect became abundant in many counties in Tennessee, North Carolina, and Arkansas where it occurs only rarely in destructive numbers. In only two States was weevil damage lighter than usual—in Oklahoma less than since 1944 and in Texas less than in any year since 1925. Conditions favorable for the weevils continued throughout the fall and winter, and in South Carolina and Louisiana it is known that they entered hibernation in very large numbers. Unprecedented large numbers were also reported in the spring of 1950.

Benzene hexachloride, calcium arsenate, and toxaphene are the insecticides now most widely used for boll weevil control. Aldrin, chlordane, dieldrin, heptachlor, and lindane are promising materials that are being tested extensively and have been used effectively in some areas or under certain conditions.

In general, dusts and concentrated sprays were about equally effective when the same amount of toxicant was used. The sprays were in general better than dusts early in the season when the cotton plants were small, and the dusts usually gave better results late in the season when the plants were large and the weevils abundant.

In order to control other pests of cotton occurring in fields with the boll weevil, much experimental work was done with mixtures of two or more insecticides.

In Mississippi weevils were killed more rapidly by aldrin or benzene hexachloride than by dieldrin or toxaphene. An emulsion containing 0.12 pound of dieldrin per acre held the infestation lower and resulted in a greater yield of cotton than emulsions containing 1.14 pounds of

chlordane, enough benezene hexachloride to give 0.64 pound of the gamma isomer, 0.35 pound of aldrin, or 3 pounds of toxaphene applied at the same rate.

In South Carolina toxaphene, toxaphene plus DDT, chlordane plus DDT, benzene hexachloride plus DDT, and dieldrin gave about equal control whether applied in dusts or emulsion sprays when the same amounts of toxicant were used.

In central Texas a 2.5-percent dieldrin dust gave a significantly higher yield than a dust containing 20 percent of toxaphene, and a dust mixture containing 2.5 percent of aldrin, 5 percent of DDT, and 40 percent of sulfur was as effective as 20-percent toxaphene. In one experiment a 2:1 mixture of aldrin and DDT applied in a spray gave better control and higher yields than similar mixtures of toxaphene or chlordane with DDT.

In Louisiana calcium arsenate and a 3:5:40 mixture of benzene hexachloride, DDT, and sulfur gave satisfactory boll weevil control when used alone or where applications of the two insecticides were alternated in the same field. Aldrin and dieldrin also gave satisfactory results.

In Madison Parish, La., serious bollworm and tobacco budworm infestations developed in cotton fields that had been treated with chlordane spray for weevil control. The spray was applied by airplane at the rate of 1 pound of the toxicant per acre at intervals of 6 to 8 days. In other fields treatments with a 10-percent chlordane dust were also followed by bollworm build-up. In all cases where bollworms and tobacco budworms were troublesome there was or had been an aphid infestation.

Early-Season Application of Insecticides Important in Central Texas

A large-scale experiment in early-season application of insecticides for the control of cotton insects was conducted in central Texas in 1949. The boll weevil causes the most damage in this area, but the cotton fleahopper and several species of thrips are often injurious early in the season. The bollworm appears later and is the most difficult cotton insect to control.

Nineteen adjoining cotton fields in two communities near Waco were sprayed or dusted with one of the all-purpose insecticides for control of cotton insects. The dusts contained sulfur plus toxaphene or a mixture of benzene hexachloride or chlordane with DDT. Emulsions containing toxaphene or a mixture of toxaphene or chlordane with DDT were applied as low-gallonage, low-pressure sprays. Two applications were made, on May 31 and June 8. Both sprays and dusts gave seasonal control of the boll weevil in two-thirds of the fields. Thrips and fleahopper populations were also reduced. The fruiting and maturity of the cotton plants were hastened by approximately 3 weeks, and the production of lint cotton was 415 pounds per acre, more than twice as high as in untreated fields nearby.

To determine whether cotton that receives the early-season treatment can mature a full crop without later treatment for the bollworm, a portion of each field in one community was given two late-season treatments for control of this pest, and the other portion was left untreated. Many of the fields produced a full crop of cotton before the bollworms appeared. The late treatments increased the yield by less than 10

percent. In the untreated portions beneficial insects undoubtedly contributed greatly to bollworm control. These results emphasize the importance of timing the early treatments so that beneficial insects may have an opportunity to reestablish themselves before late-season treatments are made, should they be found necessary.

DDT Added to Toxaphene Improves Bollworm Control

Although 1949 was a year of light bollworm damage to cotton, serious losses occurred in some districts. The first reports of injury were received from the Lower Rio Grande Valley of Texas during May. By July and during August serious injury was reported in Texas, New Mexico, Arizona, Oklahoma, and Louisiana. Most of the infestations were brought under control by natural enemies or by the use of poison.

DDT and toxaphene are the insecticides now most widely used for bollworm control. Calcium arsenate, lead arsenate, and cryolite are less effective but may be used in emergencies.

In experiments for bollworm control near Waco, Tex., DDT alone at 1 pound and toxaphene at 2 pounds plus DDT at 1 pound per acre, applied in sprays, gave significantly higher increases in yield than toxaphene alone at 2 pounds per acre. A 20-percent toxaphene dust at 15 pounds per acre did not give quite so good control as did a spray containing 1½ pounds of toxaphene plus ¾ pounds of DDT. A dust mixture containing 10 percent of DDT and sufficient benzene hexachloride to give 2 percent of the gamma isomer gave excellent control of the bollworm in several experiments when applied at 10 to 12 pounds of dust per acre.

Parathion and Benzene Hexachloride Best Insecticides Tested Against Cotton Aphids

Parathion and benzene hexachloride were the most effective of a large number of new insecticides evaluated for control of the cotton aphid in field tests in Mississippi. Eight treatments with dusts containing 0.25 to 1 percent of parathion or benzene hexachloride containing 1 percent of the gamma isomer gave complete control when applied at the rate of 10 pounds of the dust per acre. The same number of treatments with benzene hexachloride applied as a concentrated spray at 0.1 pound of the gamma isomer per acre were also 100 percent effective.

Aphids as a rule are not serious pests of cotton except where insecticides are used for control of other pests. Calcium arsenate and DDT are especially likely to cause heavy aphid populations to build up. In addition to nicotine and rotenone, which have long been used for cotton aphid control, benzene hexachloride, parathion, and tetraethyl pyrophosphate are now being used extensively for this purpose.

Cotton Plants Treated With Octamethyl Pyrophosphoramide Toxic to Aphids and Mites

Further evidence was obtained that octamethyl pyrophosphoramide may be taken up by cotton plants in quantities lethal to spider mites

feeding on them. This treatment was also found to kill aphids on cotton, but not boll weevils, bollworms, or several other cotton insects. The cotton fleahopper was affected only by much higher dosages than were needed to kill aphids and mites. The plants absorbed the chemical from treated soil through the roots and from sprays applied to the foliage, and seedlings from seed treated at the time of planting were also toxic to mites and aphids. Experiments on this systemic action were conducted with funds supplied under the Research and Marketing Act.

Mixed Insecticides Control the Pink Bollworm as Well as Other Cotton Insects

In areas where cotton growers must combat the pink bollworm as well as other insect pests, mixtures of insecticides are the most satisfactory. Since DDT is still the best insecticide known for controlling the pink bollworm, it is included in all spray and dust mixtures.

In experiments in Texas DDT combined with toxaphene, lindane, or chlordane was slightly more effective when applied in sprays than in dusts. Dusts containing benzene hexachloride, toxaphene, or lime-free calcium arsenate plus parathion or benzene hexachloride, in addition to DDT, gave satisfactory control of both the pink bollworm and the boll weevil.

In tests conducted in cooperation with the Mexican Government, DDT or toxaphene mixed with other insecticides was applied to field plots at Torreon. Of five formulations tested, one containing 10 percent of DDT, enough benzene hexachloride to give 2 percent of the gamma isomer, and 40 percent of sulfur was the most effective against the pink bollworm. This mixture ranked second in control of the boll weevil, the cotton aphid, and stink bugs, and third against spider mites and the bollworm.

Pink Bollworm Quarantine and Control Activities

Inspections show reduced infestation

For the first time since 1941 intensive inspection of the cotton crop showed no spread of pink bollworms to new areas. Negative results were obtained in 64 counties of Arizona, New Mexico, Oklahoma, and Texas, which are within the regulated area, and in nonregulated portions of Oklahoma and Texas. Other nonregulated areas found free from infestation included the San Joaquin Valley of California, southern Louisiana, Mississippi, Alabama, Georgia, northern Florida, the Mexicali district of Baja California, and the San Luis section of Sonora, Mexico.

In Arizona no pink bollworms were found for the first year since the insect was discovered there in 1927. It was the third year of negative findings in the State's great cotton-producing counties of Maricopa and Pinal, and they were released from quarantine in January 1950.

Eight regulated counties in southwestern Oklahoma and several in northwestern Texas along the perimeter of the regulated area have been found free of infestation for two successive years. In Jackson,

909586—50——5

Matagorda, and Wharton Counties, easternmost of the regulated counties in southern Texas, gin-trash inspection showed negative results for the third consecutive year. Late boll inspection in Matagorda County showed a light infestation limited to two fields.

In 73,800 bushels of gin trash from the 1949 cotton crops in the regulated area, 128,500 pink bollworms were found. All of them came from fields in Texas except 63, which came from New Mexico. In field inspections of more than 11 million bolls, blooms, and squares in these States, not a single pink bollworm was found in New Mexico, but nearly 12,000 in Texas. Gin-trash inspection showed that populations in the most heavily infested counties of western Texas were much lower than in 1948, and only a few counties showed an increase. No pink bollworms were found in any of the eight counties in west-central Texas that were placed under regulation in 1947.

Delayed stalk destruction means heavy carry-over of pink bollworms

Owing to thorough clean-up operations after the 1948 cotton crop was harvested, few pink bollworms were carried over to the 1949 season. In some sections stalks produced late crops of bolls, which in turn became infested. Boll inspection, starting in October, showed that many more pink bollworms were going into hibernation than for the past several years. Little natural mortality occurred during the mild and dry winter of 1949-50. This was expected to result in an early and more general infestation in southern Texas in 1950 than has existed there for several years.

In the Lower Rio Grande Valley a delayed but satisfactory job of stalk destruction during the fall of 1949 established a host-free condition on 725,000 acres owned by 6,829 farmers.

Bumper cotton crop taxes quarantine-enforcement facilities

Quarantine-enforcement facilities were taxed to the utmost during the handling of the 1949 cotton crop. This crop was the largest since the Federal pink bollworm control program was inaugurated. Tremendous purchases, by the Production and Marketing Administration, of cottonseed that required treatment prior to movement further added to the work load. Freeing this bumper crop of possible pink bollworm infestation so that it could move freely to noninfested sections was accomplished through the excellent cooperation of that Administration and cottonseed processors.

More than 5,770 items of contraband material were intercepted during the inspection of 237,000 vehicles halted at the three highway inspection stations operated at the border of the regulated area in the Lower Rio Grande Valley.

More than 5,400,000 bales of cotton were ginned at 1,321 gins approved for operation under the pink bollworm quarantine regulations. This is twice the quantity ginned in the same area in 1948. Approximately 2,165,000 tons of cottonseed were given a single heat treatment, and 155,000 tons originating in heavily infested sections received a second heat treatment before shipment to uninfested territory. In excess of 5 million bales of cotton and linters were compressed prior to certification, and an additional 11,400 bales of lint and linters from Mexico were vacumn-fumigated.

The year's quarantine activities included the issuance of 486,000 permits and certificates authorizing the movement of cotton or cotton products.

Methyl bromide fumigation of cottonseed in freight cars authorized

The use of forced circulation to distribute methyl bromide gas throughout loads of bulk cottonseed, which proved effective in fumigation in large steel tanks under recent provisions of the pink bollworm quarantine, was adapted to fumigation in all-metal freight cars and vans during the year. A truck-mounted blower is used to produce forced circulation by withdrawing air from the floor area in a car through floor ducts made of perforated downspouting, and returning it to the space above the load. The car door is sealed with paper, through which connections to the blower are inserted.

On February 16, 1950, the method was approved for large-scale use in certain lightly infested areas, and through June 30, 1950, 11,000 tons of seed, consisting of 307 carloads, had been fumigated to permit movement outside of the regulated area.

Cooperative work increases cotton production in Mexico

Cultural methods of controlling the pink bollworm in the field and treatment procedures at processing plants in Mexico have continued to improve. The use of insecticides has greatly increased in the La Laguna area, which for many years was considered as having the heaviest concentration of pink bollworms on the North American continent. Airplane application of insecticides was first tried in this area only 3 or 4 years ago, but in 1949 from 50 to 60 planes were in almost constant use during the period when insecticides could be successfully applied.

Stalk destruction in Mexican cotton fields adjacent to the United States was completed within prescribed dates. Availability of more power equipment resulted in considerable improvement in the type of work performed. Mexican regulations and control requirements now closely parallel those in force in adjacent areas of the United States.

Cotton production in the Matamoros area of Mexico, adjacent to the Lower Rio Grande Valley in Texas, has increased during the last 10 years from 150,000 acres to over 700,000 acres, largely as a result of this cooperative work in pink bollworm control.

Wild-cotton eradication resumed in Florida

A considerable build-up in pink bollworm infestation in wild cotton was observed during 1949 inspections in the coastal areas of southern Florida. Wild-cotton eradication was resumed there after 2 years of inactivity when funds were unavailable for this work. At the end of the 1947 eradication work, plant infestation had been reduced to about 0.1 percent. This year's inspections showed an over-all increase to 6.5 percent. An average infestation of 11 percent was found in Monroe County, where the largest number of plants are to be found. Dade County ranks next in wild-cotton growth. Pink bollworm infestation in wild cotton on several of the Florida keys has increased enormously, 42 percent of the plants there showing infestation when

the plants were destroyed in January. Present observations indicate that wild-cotton eradication was resumed just in time to prevent reinfestation of plants north of Naples, Collier County, on the west coast. Reseeding of plants with attendant scattering of seed means that this inactive period has delayed for many years the final eradication of all wild cotton in Florida.

Since this work was resumed, 32,400 acres have been cleared of wild cotton plants. An additional 16,000 acres close to known wild-cotton locations and nearly 1,400 backyard cotton plantings have been checked. In the course of these activities 84,000 wild-cotton plants have been destroyed. Over 17 million such plants have been destroyed since wild-cotton eradication was started in Florida early in 1933.

CEREAL AND FORAGE INSECTS

Grasshoppers

Control programs expanded to combat widespread infestation

The weather in the late summer and fall of 1948 and again in the spring of 1949 was extremely favorable to the development and survival of large numbers of grasshoppers throughout much of the Great Plains and Western States. In drought-stricken sections of southeastern Montana and in areas of subnormal precipitation in northern and eastern Wyoming the situation was especially critical in 1949.

The increased numbers of grasshoppers in nearly all agricultural areas and on extensive range land in several States led to an expansion of control in 1949. Baiting of range-land infestations was done on a large scale. This Bureau cooperated with State and county agencies and landowners in 22 western and midwestern States in the conduct of two types of programs—one to protect cultivated crops and the other to combat range infestation that threatened destruction of local vegetation and migration of grasshoppers to new areas.

Property owners participate in crop protection

Control measures to protect cultivated crops from damage by grasshoppers were carried out by farmers following procedures recommended and demonstrated by Bureau and State technicians.

Toxaphene, chlordane, and benzene hexachloride were used as sprays and dusts for direct control of grasshoppers even more widely than in 1948. The acreage treated increased from 1,402,000 acres in 1948 to 2,410,000 in 1949. The general availability of the insecticides in quantity, in usable formulations, and at reduced costs was an important factor in this increase. The aggregate cost for the insecticides purchased by farmers in 1949 was in excess of $3,500,000.

The crop-baiting program, though slightly less extensive than in 1948, was participated in by 34,500 farmers and ranchers in 468 counties. Landowners spread more than 13,400 tons (dry weight) of sodium fluosilicate bait on 2,549,000 acres of crop and pasture lands. This Bureau further assisted several States and counties in spreading 538 tons of bait on egg-bed infestations, roadsides, and other rights-of-way where grasshoppers were threatening crops. Almost 29,000 miles of roadsides were baited.

Baiting gave protection to more than 7,422,000 acres of crop and pasture lands. Savings resulting from this cooperative effort amounted to approximately $55 for each dollar expended. Nevertheless, grasshoppers destroyed an estimated $27,376,000 worth of crops.

Cooperative programs combat range infestations

Emergency measures were taken by this Bureau in cooperation with States, counties, and landowners to combat the heavy range infestations that had developed in Wyoming, Montana, Arizona, Nevada, and Oregon. In Montana and Wyoming two types of areas were set up, primary and secondary. Primary areas were designated as those with the heaviest grasshopper populations at the time of the nymphal surveys in the spring of 1949. In these areas application of dry bran-chlordane or toxaphene-oil bait was made by Government-owned or contract aircraft. In secondary areas, those lands lying outside of but near treated primary areas, ranchers and farmers were furnished bait for distribution chiefly by privately contracted planes.

A DC–3 airplane was purchased and equipped with special apparatus for distributing bait uniformly on extensive range land. With it the average area baited per day was 7,500 acres, and the cost of applying bait was materially lower than by any other means used heretofore.

Thirty-eight contract and three Government-owned airplanes were employed by the Bureau in the primary area. The contract aircraft in 6,787 hours of flying time treated 1,758,000 acres, and Bureau planes in 733 hours treated 461,000 acres of range. Privately contracted aircraft baited 678,000 acres in the secondary areas. Combined operations in the bi-State range work involved the spreading of 13,648 tons of a dry bran impregnated with an oil solution of either chlordane or toxaphene.

In southern Arizona late-summer baiting of range was accomplished entirely by Bureau aircraft, including a DC–3 and an N3N. Approximately 26,000 acres were treated with 125 tons of dry bran bait. A small amount of baiting with ground equipment was done in northwestern Nevada and southeastern Oregon to combat unusually heavy infestations of a migratory species.

The cost to all cooperating agencies for the 1949 range-control programs in the five States was $1,978,000.

Surveys indicate continued widespread outbreaks in 1950

During the late summer and fall of 1949 adult grasshopper surveys were conducted in 961 counties of 23 States, while egg surveys were made in 575 counties of 15 States. The surveys indicated a continuation of widespread outbreaks in 1950, despite the large volume of crop and range control work done in 1949. Range-land infestations constituted the major threat in several States. Eastern Montana faced threatening to very severe outbreaks. In Wyoming, although the size of infested areas had been decreased by control work in 1949, it will be necessary to reduce infestations further on range lands. Infestations in California were expected to be up slightly, and those in North Dakota might be more serious than any since 1939.

New grasshopper baits and sprays tested

In tests with grasshopper baits it was found that dry bran baits containing chlordane or toxaphene were as effective after storage for 6 to 12 months as they were when freshly mixed. Exposure of these baits to direct sunlight on bare ground up to 52 hours when soil-surface temperatures ranged from 110° to 140° F. caused no appreciable reduction in their efficiency.

In the range grasshopper control program in Montana and Wyoming it became important to know whether the number of flakes of poisoned bait one grasshopper would eat could be reduced by increasing the proportion of toxicant in the bait. Tests showed that increasing the quantities of chlordane from 0.75 pound to 4 pounds, of toxaphene from 1 pound to 4 pounds, and of aldrin from 0.1 pound to 1 pound per 100 pounds of bran did not decrease the number of flakes eaten by individual grasshoppers before dying. The tests also indicated that increasing the quantity of bait is more effective against heavy grasshopper infestations than increasing the concentration of the toxicant in the bait. Aldrin, dieldrin, heptachlor, lindane, and methoxychlor also showed promise in experiments with sprays and baits for grasshopper control.

Migratory grasshoppers in Nevada identified

Studies of the taxonomy of the grasshoppers involved in the current outbreak in migratory forms in the Great Basin area of Nevada and adjacent States have materially clarified the identity and distribution of the forms concerned. The dominant species had been misidentified as *Melanoplus occidentalis* (Thos.) and had to be described as new; it was given the name *M. rugglesi* Gurney. It was also necessary to be able properly to differentiate it in its various phases from all related species before the limits of the outbreak could be defined or before the probable ultimate limits could be predicted.

Mormon Cricket Infestations Continue to Decline

During 1949 the acreage in the Western States infested with Mormon crickets was the smallest in 12 years. This Bureau cooperated with States, counties, and landowners of Colorado, Oregon, and Washington in combating the heaviest infestations. Control was required in only eight counties of the three States, and the work was done mainly on range remote from cultivated lands. In all, 82,000 acres of infested lands were baited by the cooperators, of which 79,000 were treated with ground equipment. A Bureau-owned DC–3 plane baited 3,000 acres of rugged terrain in the Zenobia Basin of Moffat County in northwestern Colorado, which has been the focal point of extensive outbreaks in the past. Crop and range damage was slight in 1949. Surveys indicated a continuation in 1950 of light and moderate infestations in these three States. Certain areas in Idaho, Montana, Nevada, Utah, and Wyoming will require checking, and possibly control, to assure that crickets do not build up to outbreak numbers.

Chinch Bugs and Cutworms Cause Little Damage

Chinch bug incidence in the Central and Midwestern States continued low during 1949. Infestations were localized, and damage by

the bugs was confined to widely scattered fields. Farmers in only a few counties of five States used federally provided barrier materials to halt movement of the bugs into crops. Crop-protective measures included the use of 2,000 gallons of creosote oil and 1,800 pounds of dinitro-orthocresol dust.

Surveys of chinch bugs in hibernation made in 180 counties of 8 States late in the fall indicated that, unless dry weather prevailed in the spring and summer, widespread infestations were not likely in 1950, although locally destructive numbers might develop.

Outbreaks of armyworms and army cutworms occurred in scattered localities of a few States. To control them farmers spread 142 tons of bait provided by the Federal Government.

Parathion Recommended for Control of Greenbug Outbreak

A severe outbreak of the greenbug attacked small grains in the North-Central States in the summer of 1949, and another occurred in the South-Central States early in 1950. In North Dakota the 1949 infestation was the most serious on record, and in Oklahoma the 1950 infestation was the worst since 1907. In Oklahoma about 3 million acres were infested. Practical methods of control with insecticides developed during 1948 and 1949, in cooperation with the Oklahoma and North Dakota Agricultural Experiment Stations and insecticide manufacturers, were widely used by growers during these outbreaks. An estimated 500,000 acres of small grains in Oklahoma as well as large acreages in Kansas and Texas were treated by aircraft and ground equipment, and about 200,000 additional acres would have been treated had the weather during the height of the infestation been more favorable for control operations.

Parathion was found to be the most effective insecticide for control of the greenbug and was recommended in the spring of 1950 for use in either sprays or dusts, applied with power equipment only, including aircraft. Application with hand equipment is not advisable because of the hazard to operators. Dosages of 3 to 4 ounces of actual parathion per acre gave excellent control. Tetraethyl pyrophosphate at the rate of 4 to 5 ounces per acre also gave satisfactory control when the temperature was 65° F. or above. These insecticides are highly toxic to man and livestock. They must therefore be used with great care and only by persons who are experienced in handling and applying dangerous chemicals. Before 1949 no practical method of controlling this insect was known.

European Corn Borers in Corn Belt at All-Time High

The known occurrence of the European corn borer was extended by 145 counties in 10 States, according to observations made in 1949 in cooperation with State agencies. Counties known to be infested by the borer at the end of that year totaled 1,312 in 29 States. The principal extension of the infested area was in Kansas, Nebraska, and North and South Dakota. The borer is now present throughout the Corn Belt.

Borer populations in the Corn Belt reached outbreak numbers in 1949. They were heaviest in a rather wide zone extending from west-central Ohio northwesterly to southeastern South Dakota. Iowa averaged 802 borers per 100 plants, and one district in northwestern

Iowa averaged 1,561 borers, a fourfold increase over 1948. Illinois was the second most heavily infested State, averaging 383 borers per 100 plants. In Minnesota populations averaged 350 and in Ohio 309 borers per 100 plants; in Indiana and South Dakota they were almost as high. The total estimated loss to grain corn in 1949 was 313,819,000 bushels, valued at $349,635,000.

In areas subject to heavy losses from this pest, the Bureau assisted the State agencies in providing information on the proper use of insecticides. The cooperative program included (1) field observations to obtain factual data on the seasonal development and abundance of the borer in relation to the corn crop, (2) analysis and appraisal of the data to determine the need for and timing of insecticide treatments, and (3) the prompt issuance of such information with recommendations to farmers and insecticide distributors by special bulletins and press and radio releases. The service was of great value, not only to farmers, but to extension agents, newspapers, radio stations, canning companies, hybrid seed corn growers, insecticide companies, and other agricultural agencies. Over a million acres of corn were treated with insecticides for borer control in 1949. Without the efficient service supplied by the cooperating agencies, a much smaller acreage would have been treated and a large portion of the treatments would have been less effectively applied. It was also evident that a considerably larger acreage could have been treated with profit.

In contrast to the increase in borer populations in the Corn Belt, the borers were generally less abundant in 14 eastern States. In these States counties that averaged 83 borers per 100 plants in 1948 averaged only 46 in 1949.

The Bureau's main European corn borer laboratory was transferred, in March 1950, from Toledo, Ohio, to Ankeny, Iowa, where research on all aspects of the problem is to be conducted in cooperation with the Iowa Agricultural Experiment Station. Some of the studies on the resistance of corn plants to borer attack will be continued at Toledo, where they have been in progress for many years.

Corn Earworm Controlled with DDT Sprays

Growers of sweet corn have obtained good control of the corn earworm with sprays containing DDT in mineral oil. This treatment was recommended early in 1949 on the basis of experiments conducted in cooperation with several State experiment stations. In further tests a single spraying with 0.5 percent of DDT in mineral oil of 80–85 seconds Saybolt viscosity was very effective when properly applied to individual ears soon after they had been fertilized. Two or three sprayings with an emulsion containing 0.75 percent of DDT and 5 or 10 percent of mineral oil gave good control when applied either with hand sprayers to individual ears or by power machines with fixed nozzles.

In machine application a pressure of 150 or more pounds per square inch at the nozzles gave a higher percentage of wormfree ears than 100 pounds. Two and four nozzles per row gave about equal results provided 25 gallons of emulsion was applied per acre. Nozzles delivering flat and hollow-cone spray patterns gave equal results when the output was the same. For treating small fields a garden sprayer

powered with a gasoline motor or a hand pump-up type unit was used successfully to make applications to individual ears.

Timing of the sprays was found to be very important. Three applications of emulsion 2 days apart beginning 1 day after the start of silking gave the best results. For a two-application schedule, the first should be made 1 day after 10 percent of the ears are in silk and the second 2 or 3 days later. Use of varieties with little tillering and planting the corn at least 9 or 10 inches apart in the row resulted in more effective earworm control.

Since the development of this practical method of controlling earworms, hundreds of carloads of sweet corn are now being produced in the South for early northern markets. Formerly the commercial production of sweet corn in the South was very much limited by heavy earworm infestations.

Fumigation of Grain Stored in Quonset Huts and Hangars

That grains in emergency storage, such as Quonset huts and airplane hangars, can be protected against insects by fumigation was indicated in experiments conducted in Kansas and Illinois, in cooperation with the Production and Marketing Administration and the Commodity Credit Corporation.

A Quonset hut containing 128,000 bushels of corn was fumigated with a 3:1 mixture of ethylene dichloride and carbon tetrachloride containing 5 percent of ethylene dibromide, at the rate of 2.4 gallons per 1,000 bushels. The fumigant was applied through the roof ventilators by means of an orchard-type power sprayer. The kill of adult granary weevils planted in check boxes throughout the corn was fairly high, but many of the immature forms survived, an indication that the dosage was insufficient.

A single mass of 650,000 bushels of wheat stored in a Navy aircraft hangar was fumigated with a 1:4 mixture of carbon disulfide and carbon tetrachloride to control an infestation of stored-grain insects. The wheat was piled unevenly, averaging about 20 feet in depth at the center and rounding off to the hangar floor at the edges. It was treated at the rate of 3⅓ gallons of the fumigant per 1,000 bushels, applied in about 20 minutes by two men spraying the surface of the grain, using ¾-inch nozzles attached to 1-inch hose lines supplied through a booster pump from a tank truck. The over-all kill was 97 percent. One area required a second fumigation a week later because of poor kill due to crust on the surface grain. Two months after the first fumigation insect populations were rapidly increasing in some sections of the wheat mass, and high temperatures were recorded, particularly in the lower portions. The second fumigation greatly reduced insect activity, with consequent lowering of the temperature of the grain by 30° F. This wheat was fumigated again later.

Ryania Recommended for Sugarcane Borer

Ryania is now recommended as well as cryolite for control of the sugarcane borer in Louisiana. Treatments should be made four times at weekly intervals, beginning as soon as eggs appear in large numbers. A 40-percent ryania dust should be used at 10 pounds per acre

for each treatment. The dust should be applied while the air is quiet and the plants are wet with dew, which is usually between 6 p. m. and 9 a. m. This recommendation is based on extensive tests with this insecticide which were begun in 1945. Since then it has been tested against this insect in both small and large plots treated by airplane at various times of the year.

In small-plot experiments ryania and cryolite gave about equal control of first-generation borers, but in two airplane dusting experiments cryolite was slightly better. At harvesttime a somewhat lower percentage of joints had been bored in the plots dusted with cryolite, but the yield of sugar was 111 pounds per acre greater in the plots treated with ryania. Against second-generation borers ryania was slightly more effective than cryolite in small plots, but in airplane dusting experiments the two dusts gave practically the same borer control and increase in yield of sugar. There was little difference in effectiveness against fourth- and fifth-generation borers infesting summer-planted cane.

Yellow sugarcane aphids did not build up so much following treatments with ryania for control of second-generation borers as has been observed following treatments with cryolite. No leaf injury has ever been observed on sugarcane from the use of ryania, and very little after the use of cryolite.

Benzene Hexachloride and Chlordane Most Effective Against Clover Root Borer

Several of the new organic insecticides were tested in surface treatments against the clover root borer in Ohio. They were applied as dusts containing 1 percent of the toxic ingredient. Fall applications of benzene hexachloride at 1.25 pounds of the gamma isomer and chlordane at 5 pounds per acre reduced the populations 99 and 96 percent, respectively. In treatments applied in the spring chlordane at 5 pounds, aldrin at 2 pounds, benzene hexachloride at 1.25 pounds of the gamma isomer, and parathion at 5 pounds per acre were about equally effective against this insect, causing population reductions of 85 to 95 percent. The application of insecticides to the same plots in both fall and spring did not increase their effectiveness. Parathion at 5 pounds per acre was not effective as a fall treatment. DDT and toxaphene at 5 pounds per acre and methoxychlor at 10 pounds were not effective. Before any of these materials can be recommended for practical use, further research is needed to determine their residue hazards.

Investigations on Rhodes-Grass Scale Expanded

Studies on the Rhodes-grass scale and its control were expanded during the year upon an allotment of funds under the Research and Marketing Act. This scale was first reported in the United States on Rhodes grass at Kingsville, Tex., in 1942, and had become a serious pest of this grass in southwestern Texas by 1946. It is now known to infest 31 counties in southern Texas, 2 counties in Florida, and 1 parish in Louisiana. The infestation in Texas appears to be confined to the area south of a line running east and west from Houston to San Antonio and Del Rio.

Rhodes-grass scale is principally a pest of grasses, specimens having been collected from 38 species in Texas. It has been found in greatest abundance in Johnson grass, Rhodes grass, Bermuda grass, and St. Augustine grass. On one ranch in Texas over 100,000 acres of Rhodes grass have gone out of production because of infestation by this scale. Severe damage has been observed on Bermuda grass and St. Augustine grass on golf courses and lawns in the Rio Grande Valley.

Importation from Hawaii of one of the known parasites of the scale for release in infested areas was initiated early in 1949 in cooperation with the Texas Agricultural Experiment Station. After a laboratory method had been developed for rearing large numbers of this parasite, *Anagyrus antoninae* Timberlake, it was released in Kleberg County and the Rio Grande Valley in Texas. The parasite reproduced one or more generations in at least five locations, at one of which it apparently is well established.

JAPANESE BEETLE

Aldrin and Dieldrin Kill Grubs in Turf and Soil

The search for more effective means of controlling Japanese beetle grubs has been continued. Aldrin and dieldrin appeared to be very effective against third-instar grubs in preliminary tests. When aldrin was mixed with soil at the rate of 3 pounds per acre to a 3-inch depth, the time required to kill half the grubs ranged from 15.4 days at a temperature of 50° F. to 2.3 days at 80°. In well-drained turf treated at about the same rate 85 percent of the grubs were dead 4 weeks later. In poorly drained turf the material was not quite so effective. The growth of most of the vegetables and flowering plants tested was not affected by this soil treatment, but string beans and celery were definitely retarded. As little as 1½ pounds per acre affected the growth of beets, carrots, radishes, turnips, cucumbers, peas, and spinach. The growth of morning-glory was retarded by 1½ pounds of aldrin per acre, and that of sweet pea and zinnia by 3 pounds.

Comparable tests with dieldrin gave very similar results. At 3 pounds per acre both aldrin and dieldrin appeared to have initial effectiveness equal to that of 25 pounds of DDT or 10 pounds of chlordane, which are recommended treatments. Further studies are being undertaken with both aldrin and dieldrin.

Airplane Applications of DDT Control Beetles on Corn

Good control of adult Japanese beetles in cornfields was obtained with DDT emulsions and dusts applied by airplane early in the silking period. The emulsions, even at dosages as low as 1 pound of DDT per acre, reduced beetle populations about 90 percent and the residues remained effective for at least 8 days. Dusts applied at 1½ and 3 pounds of DDT per acre were as effective initially, but they lacked the residual effectiveness of the emulsions. The tests indicated that thoroughness of application is very important and that some proprietary emulsions may not be so effective as others. The Japanese beetle injures corn by destroying the developing silk on the ears, thus preventing pollination. The DDT treatment is not recommended for corn when the fodder is to be fed to milking cows or to animals being fattened for slaughter.

Control and Quarantine Measures Curb Spread of Beetles

The great hazard of aircraft as disseminators of Japanese beetles has been curbed by special treatments of both planes and airfields. With the cooperation of military and commercial airline personnel, airplanes flying from beetle-infested areas are sprayed and aerosoled with DDT. A total of 14,800 treatments of aircraft were made during the year at 48 airfields in the heavily infested areas. As a further precaution, foliage on and in the vicinity of airfields is sprayed and beetles are picked from boarding passengers and cargo.

To measure the effectiveness of these treatments, traps baited with a Japanese beetle attractant were operated at 104 landing fields in 31 States outside the generally infested area. With the aid of military personnel in the Western States it was possible to make trapping a Nation-wide operation. Twenty-eight beetles were caught near Atlanta, Ga., but they probably came from an earlier infestation in the city, and a single beetle was trapped near Kansas City, Mo. No beetles were caught at the other airfields where traps were placed.

Surveys in 1949 showed little spread of the Japanese beetles to new areas. However, there was a large increase in the generally infested area in eastern Pennsylvania and Virginia. Beetles were more numerous in southeastern North Carolina, and in West Virginia a number of sizable infestations were detected for the first time. In some parts of the older infested area there were fewer beetles than in 1948. Abundance in a given year depends largely on the rainfall during the summer months of the preceding year, especially where biological control has not been established. Because of unusually high temperatures and a scarcity of rainfall in the summer of 1949, it was predicted that populations in 1950 would be comparatively low in most areas.

Although both traps and manual scouting were used in these surveys, increased attention was given to manual scouting in plant-growing areas, performed where possible by temporary but experienced scouts acquainted with their work areas. Japanese beetle and white-fringed beetle scouts looked for both insects in their respective territories.

Only small additions were made to the regulated areas in Virginia, West Virginia, Ohio, and New York during the year. The North Carolina State quarantine was revised to conform to Federal procedures, and additional areas were placed under quarantine. Other States entered into agreements with plant growers to restrict shipments from lightly infested, nonquarantined areas. Eighty outlying infestations found during the year or earlier received soil or foliage applications of insecticides, so that quarantine action was not necessary.

Restrictions on the movement of farm produce subject to infestation by flying Japanese beetles were instituted in local areas on the basis of conditions observed in these areas. This procedure reduced inspection costs and inconveniences to growers and shippers. Highway inspection stations for truckers were operated at the limits of the Japanese beetle regulated area near the Virginia-North Carolina line, and spot checks were made on highways at the periphery of the regulated area in other sections.

Large volumes of nursery stock, vegetable and berry plants, cut flowers, and fresh fruits and vegetables were certified for movement

from infested to noninfested areas during the year. The principal items were 97,622,833 plants, 22,147 packages of cut flowers, and 5,215 truck and car loads of fresh fruits and vegetables. Their estimated value was $14,575,970.

The Japanese beetle exploratory and control work near Cincinnati, Ohio, was supported by civic organizations as well as city and county agencies, working cooperatively under Federal-State supervision. Some Japanese beetles were found at several locations in and about the city. DDT was applied to the foliage at all these locations, and to the soil in limited areas. The control work and State quarantine agreements made it unnecessary to place the area under quarantine in 1949.

WHITE-FRINGED BEETLES

DDT Continues to Reduce Beetle Populations

Foliage applications of DDT at the rate of 0.5 to 1 pound per acre to control adult white-fringed beetles and to prevent further spread of these insects were made on 34,000 acres in the Southeastern States during 1949.

Soil treatments with 10 pounds of DDT per acre have been made on 24,000 acres of agricultural land since 1946. Residual effects of DDT in soil thus treated are now known to prevent the development of white-fringed beetle larvae for at least 5 years, thereby eliminating damage to crops and potential spread of the pest from the treated lands.

No extensive spread of white-fringed beetles was recorded during the year, except a 1,000-acre infestation in a rural area of Shelby County, Tenn., a small localized infestation in an industrial area in Chattanooga, Tenn., and urban infestations in Charlotte and Rocky Mount, N. C. White-fringed beetles are now known to be present on approximately 265,000 acres.

New Treatments Aid Quarantine Enforcement

All or substantial parts of infested nurseries or those close to known white-fringed beetle infestations have been treated with DDT applied to the soil at 50 pounds per acre. This treatment, which has been applied to more than 1,000 acres of nursery land largely at the expense of the growers or States, prevents beetle larvae from being moved in the soil of balled nursery plants, and nursery stock produced on such treated land may now be moved under certificate without further treatment. The work of quarantine inspectors has thus been materially reduced, nursery procedures have been simplified, and methyl bromide fumigation as a prerequisite to movement of nursery plants is in general no longer necessary.

Dilute activated pyrethrum solutions were adapted to the treatment of nursery plants to permit their movement under the white-fringed beetle quarantine. The solution may be applied as a dip to semi-bare-rooted plants, as a soak to potted or balled-and-burlaped plants, or as a collar treatment to nursery plants in a row. The treatment has been used when applications of DDT to the soil could not be made in time to allow movement of stock during the current season, and in

emergencies where large blocks of nursery plants intolerant to methyl bromide fumigation were quarantined because of newly discovered infestations. More than 104,000 plants were certified for movement after this treatment.

INSECTS AFFECTING MAN

The research on insects affecting man is still supported largely by funds transferred from the Department of Defense, although, as formerly, certain aspects of the work are closely coordinated with related activities under regular Bureau appropriations. The investigations for the armed services are being conducted in cooperation with the offices of the Surgeon General, the Quartermaster General, and the Chief of Engineers in the Department of the Army, the Surgeon General in the Department of the Navy, and with the Department of the Air Force.

California Lake Freed of Gnats

Clear Lake in California has apparently been freed of the gnats that have long been a serious nuisance and have prevented the environs from becoming a prosperous recreational area. In September 1949 the entire lake, which covers 40,000 acres, was treated with TDE (dichlorodiphenyldichloroethane) in cooperation with State and local agencies. The insecticide, loaded on barges pulled by tugboats, was applied as a 30-percent emulsifiable concentrate by gravity feed through small hoses attached to drums. A total of 14,000 gallons was distributed in 2 days, the dosage being 1 part of TDE in 70 million parts of water. Before this treatment hundreds of gnat larvae were found in samples of mud taken from the lake and hundreds of thousands in plankton nets, but 24 hours afterward millions of larvae were dead or dying and after several weeks none could be found although hundreds of mud samples were taken. Six months later mud samples were taken again and plankton nets were towed for several miles, all with negative results.

This achievement is unique in the field of insect control. Never has an insect infestation been eliminated at one time from such a large body of water—and this without apparent harm to fish and other beneficial organisms. The operation last fall was the culmination of several years of research and planning. The Bureau began working on this problem in 1938. Although the research project was interrupted during the war, when it was resumed in 1946 several new insecticides were available for testing. Laboratory and small-scale field experiments showed TDE to be outstanding in effectiveness against the Clear Lake gnat, and in 1948 complete control of gnat larvae in a small lake was obtained with TDE at 1 part in 75 million parts of water without injuring fish or associated aquatic life.

Residents of Lake County were greatly interested in the progress of these experiments, and in view of the success obtained in freeing the small lake of this pest they determined to proceed with a program to treat Clear Lake. A gnat and mosquito abatement district was organized, and later funds were appropriated by the county. The California State Health Department and the State Division of Fish and Game also cooperated. This Bureau provided the technical supervision in planning and carrying out the program.

Resistance of House Flies to New Insecticides Makes Control Difficult

House flies in many parts of the world have now developed a marked resistance to DDT. Some of these flies are also difficult to control with methoxychlor, a material closely related chemically to DDT. Of insecticides tested against DDT-resistant flies, chlordane in emulsion was the most consistently effective, giving at least 85 percent control for 4 to 8 weeks when applied as a residual spray to surfaces where the flies rest, at 100 or 200 milligrams per square foot. Lindane in a wettable-powder spray at 25 to 50 milligrams, dieldrin in emulsion at 50 milligrams, and toxaphene in emulsion at 200 milligrams per square foot were generally satisfactory for similar periods. However, there is evidence that flies will develop resistance to all these insecticides.

The biology and control of the house fly as an insect of medical importance to our Armed Forces is being investigated in the Middle East in cooperation with the United States Navy. In a practical control test at Quaranfil, Egypt, benzene hexachloride dust was applied once a week to all house fly breeding places, but less than a year after the first treatment satisfactory control could no longer be maintained. Laboratory comparisons confirmed the existence at Quaranfil of flies that were about 24 times as resistant to benzene hexachloride as flies from untreated towns.

DDT-Resistant Mosquitoes Raise New Problem in Florida

Resistance of mosquitoes to DDT has been found in several areas in Florida where this insecticide has been used extensively for several years. Adult salt-marsh mosquitoes are usually controlled with 0.2 pound of DDT per acre applied as a 5-percent solution in fuel oil by aircraft. In 1949, however, several applications at this dosage and also at 0.4 pound per acre failed to control these mosquitoes. When applied in an emulsion with ground equipment, at the rate of 0.05 pound per acre, DDT gave about 80 percent reduction of larvae in areas where it had not been used before, but the same dosage showed not more than 25 percent control in an area where DDT had been used for several years.

Experiments to find an insecticide that would be effective against DDT-resistant mosquitoes were conducted in Brevard County in cooperation with the Army and local mosquito-abatement districts. Lindane showed outstanding performance against the adults and dieldrin was only slightly less effective. Chlordane and toxaphene were comparable to DDT. Parathion gave good control in open areas, but only fair control in woods. On the basis of these tests, 1 pound of lindane in 5 gallons of fuel oil, applied from the air at 0.1 pound per acre, was tentatively recommended to mosquito-abatement districts for controlling DDT-resistant mosquitoes. Technical benzene hexachloride at 0.05 to 0.1 pound of the gamma isomer was also recommended for use where it would not be objectionable.

Physiological Explanation of Resistance to Insecticides Sought

The discovery that certain insects have developed resistance to insecticides that formerly were effective against them has made it necessary to seek new methods of control. As a basis for such investigations physiological studies are under way to explain why insects

develop resistance to insecticides. It has been found that house flies that have become resistant to one insecticide also show considerable tolerance to other insecticides. A resistant strain was developed by exposure to a mixture of DDT, methoxychlor, chlordane, toxaphene, lindane, and pyrethrins. Another strain highly resistant to DDT, which had not been exposed to other insecticides, showed resistance equal to that of the first strain to both the individual components and the entire mixture. Both strains were resistant to parathion, to which neither had previously been exposed. These studies indicate that the usefulness of residual insecticides for the control of house flies may be limited.

In the nerve tissues of insects is a chemical called acetylcholine, which aids in causing impulses to be carried across nerve junctions, and the cholinesterase enzyme, which regulates these impulses by hydrolyzing the acetylcholine. Parathion and other organic phosphorus compounds are effective poisons because they inhibit this enzyme activity. The inhibiting action of the cholinesterase enzyme in the heads of resistant house flies was found to be much less than in those of nonresistant laboratory strains of flies. Studies are being continued to learn the significance of this finding.

New Insecticides Tested Against Mosquitoes

Several of the new synthetic organic insecticides have been tested in the laboratory against floodwater *Aedes* mosquitoes. As larvicides heptachlor, aldrin, and dieldrin were found to be equal to or more toxic than DDT. Heptachlor, methoxychlor, DDT, and the fluorine analog of DDT were from two to five times as toxic to these larvae at 60° F. as at 95°, but with parathion, toxaphene, and dieldrin the reverse was true.

Lindane was one of the most efficient residual poisons tested against adult mosquitoes, although not so persistent as DDT. Dieldrin, aldrin, and heptachlor were slow to cause knock down, but after a short period of contact caused complete mortality in 24 hours.

Allethrin, the new synthetic pyrethrumlike insecticide, was slightly less toxic to mosquitoes than was natural pyrethrum. The use of a synergist with allethrin caused some increase in the mortality of mosquitoes, but less than with the natural product.

Radioactive Isotopes Provide New Aids in Insect Studies

Radioactive isotopes provide a new means of studying the habits and movements of insects. By treatment with such isotopes they can be marked and then released, and later identified by means of a Geiger counter. Studies conducted in cooperation with Oregon State College showed that mosquitoes could be made radioactive by feeding them sugar solutions of radioactive phosphoric acid (containing P^{32}), by rearing them in water containing this material, and by allowing them to feed on a rat injected with it. In all cases a sufficient amount of radioactive material was subsequently found in individual mosquitoes to produce reliable records. It was found that house flies fed small doses of radioactive phosphorus would oviposit normally and that the next generation of flies would also show some radioactivity.

Radioactive isotopes are also being used in studies on the mode of action of insecticides, such as their penetration through the cuticle and metabolism within the insect. Radioactive DDT was applied to the thorax of resistant house flies, and 24 hours later the insects were washed with acetone. Measurements with a Geiger counter showed that only 18 percent of the insecticide recovered had penetrated the insect. From 63 to 71 percent of the DDT that penetrated the flies was metabolized to products that were not toxic when tested against mosquito larvae.

Taxonomists Aid Biological Studies on Punkies and Black Flies in Alaska

Critical taxonomic studies have been made of the blood-sucking flies of Alaska. Inasmuch as correct differentiation of the 6 species of punkies and 31 species of black flies was not possible in the field, these taxonomic studies were a prerequisite to the proper analysis and correlation of the biological field data acquired during the last three seasons. With the development of a classification of the immature stages of the black flies, it will now be possible to associate existing knowledge of adult habits with field observations on the ecology of immature forms and thus further the development of more efficient control measures. This added knowledge of the identity of the forms involved will also make it possible to predict which species, not now pests of man in Alaska, may become so under changed environmental conditions.

Research on Imported Fire Ant Undertaken

Research to gain information on the biology, control, distribution, and economic importance of the imported fire ant was initiated in July 1949 at Spring Hill, Ala. This project is being conducted with funds authorized under the Research and Marketing Act in cooperation with the agricultural experiment stations of Alabama, Mississippi, and Florida, and the Department of Agriculture, Conservation Department, and Extension Service of Alabama.

The imported fire ant, introduced into this country about 1930, is now widely distributed in Alabama and Mississippi; it also occurs in Florida, Georgia, and Louisiana. It is not only a vicious stinging pest of man and animals, but it attacks germinating seed and young tender plants of various agricultural crops. Chlordane has been found useful for controlling this new pest. Investigations are under way to determine in what manner this insecticide can be employed most effectively and economically. Aldrin and dieldrin and the fumigant methyl bromide have also shown promise in preliminary experiments.

INSECTS AFFECTING ANIMALS

Screw-Worm Infestations Widespread in 1949

Severe and widespread attack of livestock by screw-worms was experienced during 1949. This pest normally overwinters in Florida and the southern part of Texas. In the spring of 1949, however, winter survival areas included parts of Georgia, the lower coastal area of

South Carolina, and southern Arizona and California. Before the end of the summer the infestation in the Southeast became generally distributed in South and North Carolina, Alabama, Tennessee, and in portions of Virginia, Kentucky, and Mississippi. Local infestations resulting from importation of infested livestock were reported as far north as New Jersey. The pest spread throughout the State of Texas, and infestations were reported in Arizona, New Mexico, Oklahoma, Kansas, Missouri, Arkansas, Iowa, Nebraska, South Dakota, and Indiana. Outbreaks in the last two States and in some other parts of the Midwest resulted from the importation of screw-worm infested animals.

Losses to the livestock industry were especially high in areas where owners were unfamiliar with the pest so that infested animals were not inspected and treated properly. The Bureau assisted State officials in giving advice to stockmen on animal-management practices by which they might reduce the number of infestations, and also on the treatment with smear 62 developed by the Bureau a few years ago. During the winter of 1949–50 the screw-worm overwintered even farther north than in the previous year. Stockmen were warned to prepare for another severe infestation in 1950 should the weather prove favorable. In this connection "Screw-Worms—How to Recognize and Control Infestations in Livestock" was issued as Program Aid 100.

New dressings for screw-worm wounds which appear to be more effective than smear 62 are being investigated. One of the most promising formulations contains pine oil and lindane in place of the benzene and diphenylamine in smear 62. Research is being continued to determine whether the material can be used without harming the animals.

Toxaphene and Lindane Recommended for Control of Livestock Pests

Toxaphene has been recommended for controlling flies, lice, and ticks on beef animals, lice on swine, sheep, and goats, and the sheep tick. For ticks, lice, and horn flies on beef animals a spray containing 0.5 percent of toxaphene is suggested. Treatments every 2 to 3 weeks will control the lone star and Gulf Coast ticks. One or two treatments during the season is sufficient for the winter tick. One treatment will usually provide satisfactory control of the common lice of cattle, but for horn flies the treatment should be repeated every 3 to 4 weeks. This insecticide should not be used on dairy cows or in dairy barns until more is known about its occurrence in the milk.

A tentative method has been developed for determining the concentration of toxaphene in emulsions in cattle-dipping vats, when it is known that toxaphene is the only insecticide present. The method, which can be used at the vat, consists in extracting the toxaphene from a sample of the dip with isooctane and measuring the specific gravity of the extract. Comparison of results obtained by this method with those obtained by analysis of dip samples for total organically bound chlorine showed accuracy of ± 0.05 percent for concentrations up to 1 percent of toxaphene.

Lindane is recommended for controlling all kinds of lice on livestock, including dairy cattle, and the sheep tick. For ticks on beef cattle a spray containing 0.025 percent of lindane and 0.5 percent of

DDT is more satisfactory than lindane alone. Lindane will kill engorged forms of all the common species attacking livestock. DDT is relatively ineffective against engorged ticks, but it remains on the animal for longer protection against reinfestation.

Lindane Effective Against Pests of Poultry

Lindane has been found especially promising for the control of poultry pests. Thorough treatment of poultry houses and other roosting places with 0.2–0.4 percent lindane sprays is effective against the chicken mite and the fowl tick. Roost paint containing 3 percent of lindane has given excellent control of the chicken body louse. A light mist spray containing 1 percent of lindane applied to roosting chickens is also effective against lice, but further experiments will be necessary to determine whether this spray can be applied without harming the birds.

Sprays containing 0.5 percent of chlordane or toxaphene also show promise of controlling mites and ticks when applied to poultry houses.

Procedures for Evaluating Insecticides Improved

Special techniques for evaluating insecticides and repellents for controlling flies, principally the stable fly, have been developed which permit investigations to be conducted with a minimum of personnel and other services. At the Kerrville, Tex., laboratory mice instead of cattle or other livestock are utilized for preliminary evaluation of candidate insecticides and repellents. Promising materials are then applied to cattle which are exposed to laboratory-reared flies in screened stalls. With the improved procedures several times as many chemicals can be tested at lower cost than was formerly possible.

At the Orlando, Fla., laboratory large numbers of insecticides can now be rapidly evaluated against the house fly by the use of small, accurately calibrated loops devised for applying the insecticide to the insect. By this method also special studies can be conducted in less time then is required with other microtechnique devices currently in use for testing insecticides.

Study of Horse Flies and Deer Flies Begun

The biology and control of horse flies and deer flies is the subject of a new project undertaken in 1949 in cooperation with the Agricultural Experiment Stations of Florida and Oklahoma, with funds provided under the Research and Marketing Act. These flies are serious pests of livestock in these States, and no adequate measures have yet been found to control them. Studies on the life history and habits of the more important species of tabanids known to occur in this country will be included in these investigations.

Toxicology of Insecticides

Studies on the toxicology of insecticides used to control livestock pests were continued with funds authorized under the Research and Marketing Act. In this work the Bureau cooperated with the Bureau of Animal Industry and the Bureau of Dairy Industry of the De-

partment of Agriculture, the Texas Agricultural Experiment Station, and insecticide producers.

Storage of insecticides in animal tissues varies

Investigations were continued to determine the extent to which various insecticides applied to cattle or consumed in their feed are absorbed and stored in their fatty tissue.

Range cattle were sprayed 12 times at 2-week intervals, the most severe treatment that is used in practice, and at various intervals after the last application fat samples taken by biopsy were analyzed by the organic-chlorine method for evidence of the insecticide. In animals treated with sprays containing 0.5 percent of toxaphene the fat showed 8 p. p. m. (parts per million) of this insecticide 2 weeks after the last treatment, but none 4 weeks later. When chlordane sprays of the same strength were used, 20 p. p. m. were found in the fat after 2 weeks, 4 p. p. m. after 6 weeks, but none 10 weeks later. When benzene hexachloride was applied in sprays containing 0.025 percent of the gamma isomer, 31 p. p. m. were found in the fat after 2 weeks but within 10 weeks it disappeared. These experiments indicate that there is less tendency for toxaphene, chlordane, and benzene hexachloride to be stored and they are eliminated from the animal's system more rapidly than are DDT and TDE.

In another experiment feed with which lindane had been mixed at various rates was fed to Hereford cattle for 10 weeks, and at the end of this time samples taken by biopsy were examined for evidence of this insecticide. Little or no lindane had accumulated in the fat of two animals receiving 1 p. p. m., about 8 p. p. m. was present in that of two animals receiving 10 p. p. m., and about 100 p. p. m. in those receiving 100 p. p. m. However, in fat samples taken 6 weeks after normal feeding was resumed very little lindane was found. It was therefore concluded that this insecticide is soon eliminated from the animal.

Insecticides in milk and milk products studied

In 1948 it was reported that DDT had been found in the milk of dairy cows treated with this insecticide or following its use in dairy barns. For this reason the Bureau, in cooperation with various other Government agencies and the insecticide industry, has been experimenting with other insecticides for this purpose. In 1949 methoxychlor and pyrethrum insecticides were recommended for application to dairy cows, and methoxychlor and lindane as residual sprays in dairy barns and other buildings where milk is processed.

Recent experiments in cooperation with the insecticide industry indicate that lindane applied to dairy barns for house fly control did not contaminate the milk. When it was applied to dairy cows, small amounts appeared in the milk but, unlike DDT, this insecticide did not persist for long periods of time. When applied to cows as a 0.05-percent spray, a maximum of 1 part of lindane per million was found in the milk during the first 24 hours and none after the third day. These results are in line with those obtained in similar experiments at Cornell University. On the basis of these experiments

lindane is now recommended for application to dairy cattle at 0.03-percent strength for control of lice only.

The effect of various processing operations on the DDT content of milk products was investigated in cooperation with the Bureau of Dairy Industry. Milk from a number of cows that had received DDT was combined to provide a supply for processing on a commercial scale. Chemical analyses of the products by the Schechter-Haller colorimetric method showed the DDT content to be as follows (figures in parts per million): Raw whole milk 7.5, raw skim milk 0.2, raw cream 67.2, pasteurized whole milk 6.0, pasteurized cream 70.2, buttermilk 1.9, whey 0.5, butter 100.0, cheddar cheese 47.0.

Feeding experiments were carried out in which milk cows were fed DDT in soybean oil solution, both in capsules and mixed with grain, and as crystalline DDT. The DDT concentration in the milk showed little difference between the three methods of feeding when the same dosage was given. Increasing the daily dosage of DDT gave comparable increases in the DDT concentration of the milk. In other experiments hay made from alfalfa sprayed with DDT was fed to milk cows. Again increases in the intake of DDT increased the DDT content of the milk. The DDT concentration was more than twice as high in these hay-feeding tests as in the tests where similar dosages of DDT were fed in crystalline form or in soybean oil solution.

These studies were conducted with funds authorized under the Research and Marketing Act.

HOUSEHOLD INSECTS

New Methods Permit Testing of Insecticides Against Ants

Laboratory tests of insecticides against ants have been limited because of the difficulty of rearing the ants to produce the large numbers required. In studies to find a suitable laboratory rearing method, it was found that hard-boiled eggs, cooked hamburger, and house fly larvae and pupae were good nutrients for several species of ants. Suitable containers for ant colonies were devised. Flourishing laboratory colonies of four species—the little black ant, the Pharaoh ant, the Argentine ant, and the fire ant—are now being maintained.

A technique for conducting laboratory tests with ants was also developed. The relative effectiveness of DDT, TDE, toxaphene, methoxychlor, parathion, chlordane, heptachlor, aldrin, dieldrin, the fluorine analog of DDT, lindane, pyrethrum, and allethrin was determined against all four species. Chlordane and dieldrin were outstanding from the standpoints of both initial toxicity and residual effect. In general, the Pharaoh ant was most resistant to insecticides, followed in order by the fire ant, the little black ant, and the Argentine ant.

New Insecticides Protect Fabrics from Insect Damage

Laboratory tests have been completed in which many new insecticides were evaluated as mothproofing agents. The initial effective-

ness was determined, as well as that after up to three launderings or dry cleanings. The treated cloths were then aged 2 years and tested again. It was found that fabrics treated with DDT, TDE, or methoxychlor were protected against insect damage for 2 years or longer in storage.

On the basis of data obtained from this work and from special investigations carried on for the Department of Defense, this Bureau has been able to make recommendations to the Office of the Quartermaster General for the routine impregnation of woolen fabrics and garments with DDT to protect them from insect damage during storage. These recommendations have been accepted and will result in savings each year, to both the Government and the general public, many times the cost of the research leading to their development.

A method has been devised by which the housewife can mothproof washable woolens, such as blankets and sweaters, by simply adding a small quantity of DDT emulsion concentrate to the last rinse water. The cost of this treatment is only a few cents for each pound of dry wool fabric. Final details are being worked out, as well as the adaptation of this method to use in commercial laundry machines.

Preliminary tests indicate that residual sprays of chlordane or lindane are effective for the control of clothes moths or carpet beetles in buildings.

Several investigations on protection against fabric insects have been conducted with Research and Marketing Act funds. In studies to determine whether chests made of neutral woods impregnated with some of the new insecticides can be used for protective storing of woolens, lindane was the most promising material tested. Preliminary findings indicate that chests made of wood impregnated with lindane may function in somewhat the same manner as chests made of red cedar. Yarns and bristles made from casein, the corn protein zein, and other proteins have been found very susceptible to damage by insects. Tests conducted in cooperation with the Bureau of Agricultural and Industrial Chemistry have shown that incorporating DDT in casein fibers during the manufacturing process will render them insect-resistant for 18 months or longer. The successful insectproofing of these fibers will greatly improve their commercial value. Similar treatment of feathers and down and the protection of these materials during storage are being studied in cooperation with the Office of the Quartermaster General. Feathers treated with low concentrations of DDT have been protected from insect damage for more than a year. Methoxychlor and TDE are also effective, but higher concentrations are required than for DDT.

Insectproofing of Wallboards Studied

Roaches, silverfish, and some of the pests that attack stored grain sometimes damage wallboards of various types. In tests conducted with funds authorized under the Research and Marketing Act, it was found that much of the injury to these boards was caused when the insects gnaw cavities prior to egg laying or pupation, and that they also feed on casein paint or other sizing used on the boards.

Wallboards impregnated with DDT, chlordane, lindane, or dieldrin have been found resistant to insect damage. Mortality of roaches was

high when they were confined on treated boards. Wallboards treated in this manner may aid in controlling infestations as well as preventing defacing damage.

CHEMICAL STUDIES OF INSECTICIDES

Scabrin, a New Insecticidal Chemical Found in Common Weed

A new insecticidal material which in preliminary laboratory tests was several times as toxic as the pyrethrins to house flies has been found in the roots, stems, and leaves of *Heliopsis scabra*. This plant, known as ox-eye and related to the sunflower, is a common weed in many parts of the United States. By extraction of the roots, which are the most toxic part of this plant to insects, two insecticidal oily fractions have been obtained. One of these oils has been isolated in pure form and shown to be either N-isobutyl-2,4,8,10,14-octadecapentaenamide or an isomer of this compound.

This new chemical, which has been named "scabrin," is much like affinin, an insecticidal compound previously isolated by Bureau chemists from the roots of the Mexican species *Heliopsis longipes*, and is also similar to herculin, which they recently obtained from the bark of the southern prickly-ash tree.

An insecticidal compound, which appears to be identical with scabrin, also has been obtained in small amounts from the roots of *Heliopsis parvifolia*, another species native to the United States.

Further work must be done to determine the effectiveness of scabrin against insects other than house flies, whether it would be safe for general use, and whether it can be produced profitably and in sufficient quantity.

These studies were conducted with funds authorized under the Research and Marketing Act.

Allethrin, a Synthetic Pyrethrinlike Insecticide, Now in Commercial Production

The allyl homolog of cinerin I, one of the pyrethrinlike esters recently synthesized by Bureau chemists, is now on the market under the name "allethrin." After the synthesis of these esters was announced in March 1949, representatives of many research laboratories and insecticide manufacturers visited the Bureau's insecticide laboratory at Beltsville, Md., to learn details of the method and obtain advice on how to put it into practice. The production of allethrin in commercial quantities by March 1950 was made possible by close cooperation between the Government and industry.

Preliminary tests by Bureau entomologists indicate that allethrin is superior to the natural pyrethrins against several insect species, about as toxic to many others, but decidely inferior against some pests. Against the little black ant, the black carpet beetle, and the citrus blackfly it appeared to be more effective. The two products were about equally toxic to house flies and mosquitoes, but the natural pyrethrins were much more toxic to roaches and some aphids. The effect of synergists on allethrin also varied widely in tests against different insects and also in different strengths and formulations.

Pharmacological studies, although incomplete, indicate that allethrin is no more toxic than pyrethrins to warm-blooded animals.

Allethrin was more effective against house flies than were 21 related synthetic compounds tested against these insects.

Octamethyl Pyrophosphoramide Shows Promise as a Systemic Poison

The recent discovery that certain organic phosphorus compounds, when absorbed by plant tissues, will kill insects feeding on the plant juices has renewed interest in the use of systemic poisons for insect control. Bureau entomologists have studied this problem for many years, but none of the chemicals studied until recently have warranted further investigation. During the year outstanding results have been obtained in tests with octamethyl pyrophosphoramide, particularly against aphids and mites on cotton and in greenhouses.

In connection with the investigation of octamethyl pyrophosphoramide as a systemic poison, certain chemical studies are being made. This compound is now available only in a technical grade, and biological tests indicate that its content of active ingredient is variable. A method of assaying the technical product is now being developed. The pure compound can be obtained from the technical material by removing all ionic impurities by treatment with ion exchange resins followed by extraction with chloroform and vacuum fractionation. It is a colorless, odorless, oily liquid, which crystallizes readily on cooling and melts at about 20° C.

A sensitive colorimetric method has been developed by which as little as 2 micrograms of octamethyl pyrophosphoramide can be detected in plant material. It has been applied thus far to the determination of this compound in rose leaves that had been sprayed and in alfalfa and snap beans that were grown in treated soil. A good correlation was found between the concentration of octamethyl pyrophosphoramide placed in the soil and the quantity detected in the macerated and extracted snap beans.

Other organic phosphorus compounds tested on a small scale and found to show systemic action as insecticides were symmetrical and unsymmetrical diethyl bis(dimethylamido)pyrophosphoramide.

Further chemical studies and investigations to determine the effect of these systemic insecticides on beneficial insects and on the plant itself are necessary before this method of treatment can be recommended.

Progress in Studies on Insecticidal Plant Alkaloids

The insecticidal constituents of *Tripterygium wilfordii*, a Chinese plant introduced into this country by botanists of the Department about 10 years ago, received some preliminary study at that time by chemists of this Bureau. They isolated what was then believed to be a pure ester alkaloid which they called wilfordine. More recent investigation has shown that the supposed pure alkaloid wilfordine is actually a mixture of several alkaloidal compounds. The two major ones have been separated in pure form and called apha- and beta-wilfordine. On the basis of elementary analyses and molecular

weight determinations, they have been tentatively assigned the empirical formulas $C_{44}H_{49}NO_{19}$ and $C_{42}H_{51}NO_{20}$.

In connection with the investigation of *Nicotiana glauca*, the wild tree tobacco, as a source of anabasine for use as an insecticide, two new colorimetric tests have been developed for distinguishing between the three closely related alkaloids anabasine, nicotine, and nornicotine, which sometimes occur together in *Nicotiana* species. In one of these tests nornicotine and anabasine will give a red color with hydroquinone, whereas nicotine gives only a yellow color. In the other test, where the reagents 1,3-diketohydrindene and *p*-hydroxybenzoic acid in diisopropyl ketone solution are mixed with the alkaloid sample in acetone-diisopropyl ketone solution, nornicotine gives a deep violet color but not anabasine or nicotine.

The studies on these plant alkaloids were conducted with funds authorized under the Research and Marketing Act of 1946.

Agricultural Wastes Tested as Diluents for DDT Wettable Powders

The testing of agricultural waste products as insecticide diluents was continued with funds provided under the Research and Marketing Act. Wettable 50-percent DDT powders were prepared with the following waste products finely ground as diluents: Brine-floated and weathered apricot pits, coconut shells, hard component of corncobs, Douglas-fir and southern pine bark, and shells of pecan, almond, and black and English walnuts. Samples of each powder were examined for physical properties in the laboratory and sent out for entomological field tests. On the basis of physical properties, Douglas-fir bark appeared the most promising.

All the wettable powders made with these botanical diluents foamed excessively when mixed with water. Some progress was made in correcting this fault by adding antifoam agents containing silicone or by varying the type of wetting agent. Another means of improving the properties of these diluents that has shown promise is blending with mineral diluents. For example, a mixture of 4 parts of walnut-shell flour and 1 part of diatomaceous earth has been used to make a 50-percent DDT wettable powder that meets tentative Federal specifications in all respects.

Cholinesterase Inhibition Used to Measure Organic Phosphorus Spray Residues

With the recent development of several new insecticides containing organic phosphorus compounds—including parathion, tetraethyl pyrophosphate, tetraethyl dithionopyrophosphate, and ethyl *p*-nitrophenyl benzene thionophosphate—came the need of a method of determining spray residues from such materials. Such a method has been devised which utilizes the inhibiting, or inactivating, effect of these compounds on cholinesterase, an enzyme found in the nervous tissue of all animals, including insects. In fact, they are potent insecticides because they inhibit the action of this enzyme. The degree of inhibition of a particular organic phosphorus insecticide depends on its concentration and is therefore used as a measure of the amount present.

This method was first applied to the determination of tetraethyl dithionopyrophosphate spray residues, for which no other analytical method is available. On samples of lettuce and tomatoes sprayed with this material as little as 0.1 microgram could be detected. The method is thus highly sensitive. It can be used for estimating the presence of any insecticide that inhibits cholinesterase, and is therefore of particular value where no specific method is available.

Respirators and Gas-Mask Canisters Developed for Protection Against Parathion

In the handling of parathion insecticides inhalation of dust, spray, or mist is hazardous and must be avoided. A cooperative program to develop protective equipment has been carried out by Federal agencies and manufacturers of respiratory protective devices under the auspices of the Interdepartmental Committee on Pest Control. Chemists of this Bureau took the lead in developing procedures for testing respirator cartridges and filters for use against dusts and sprays and gas-mask canisters for use against vapors containing parathion. Cartridges, filters, and canisters submitted by manufacturers were tested in the Bureau, and the results reviewed under the cooperative arrangement. Several of the units tested removed a high percentage of dust, mist, or vapor and greatly reduced inhalation hazards, but none of them gave complete protection. A statement giving information on the respirators tested, with indication of those giving protection for field use of parathion dust and sprays, and on the precautions to be taken in using them, has been issued by the committee. These tests demonstrated that the respirators do not provide protection against tetraethyl pyrophosphate or hexaethyl tetraphosphate.

COMMON NAMES FOR INSECTICIDAL CHEMICALS

During the year the Bureau has indicated that it will use in its publications the following common names that have been proposed for four synthetic organic insecticides:

"Lindane" for the gamma isomer of benzene hexachloride of a purity not less than 99 percent.

"Aldrin" for a product containing not less than 95 percent of 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4,5,8-dimethanonaphthalene.

"Dieldrin" for a product containing at least 85 percent of 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4,5,8-dimethanonaphthalene.

"Allethrin" for the substantially pure chemical *dl*-2-allyl-4-hydroxy-3-methyl-2-cyclopenten-1-one esterfied with a mixture of cis and trans *dl*-chrysanthemum monocarboxylic acids. This is one of the pyrethrinlike esters synthesized by Bureau chemists, which has been developed commercially in the past year. It has also been referred to as the allyl homolog of cinerin I.

VARIOUS PARASITES IMPORTED FOR STUDY OR COLONIZATION

The small-scale importation from Europe of selected species of European corn borer parasites for further tests was continued during

the year. Shipments from France and Italy comprised 66,500 field-collected borers, some of which contained *Apanteles thompsoni* Lyle, 1,805 cocoons of *Microgaster tibialis Nees*, and 3,310 cocoons of *Campoplex alkae* E. and S.

Parasites of the European chafer reared in France and imported for colonization in the infested area in New York comprised 3,923 puparia of *Dexilla rustica* (F.) and 296 of *Microphthalma europea* Egger.

Small consignments of *Microctonus aethiops* (Nees) and *Campogaster exigua* (Meig.), parasites of the sweetclover weevil, were forwarded from France to the North Dakota Agricultural Experiment Station.

Shipments to the California Agricultural Experiment Station consisted of a small consignment of *Campoplex* spp., parasitic on the navel orangeworm, from France, and three large consignments of European elm scale material from France and Bavaria, which contained at least six species of parasites.

NEW INSECT ENEMIES IMPORTED TO CONTROL KLAMATH WEED

The two foliage-feeding beetles of the genus *Chrysolina*, imported from Australia in 1944 and following years, continue to show outstanding ability to control heavy infestations of the Klamath weed in northern California. In addition to the expansion of the colonization program with these beetles in California and the Northwestern States, importations of new enemies during the year included 1,900 roots infested with *Agrilus hyperici* Creutz, a root borer, and 4,200 leaf galls containing the gall fly *Zeuxidiplosis giardi* Kieff. One colony of the latter has already been released in northern California. These additional species are for use in limited mountain areas where *Chrysolina* is not fully effective.

HONEY BEES AND OTHER POLLINATING INSECTS

Need for Pollinating Insects Still Urgent

Crop growers, especially legume-seed producers, have become increasingly conscious of the need for bees, and in a few localities the demand for colonies is actually greater than the supply. Many beekeepers who formerly operated entirely as honey producers are now considering using their colonies primarily for pollination. Unfortunately, hundreds of others are giving up their bees entirely because of low honey prices and the failure of crop producers dependent on insect pollination to pay the beekeeper adequately for the service he can render them. It is hoped that the mandatory price support on honey passed by the Congress in 1949 will tend to stop beekeepers from going out of business too precipitately, and thus prevent the disastrous consequences to agriculture that would result if the number of colonies of bees becomes too low. Inasmuch as price support is a temporary aid, the development of an equitable basis whereby the fruit and seed producers recompense the beekeeper for the services of his bees would give more permanence to this important service. At present it is available largely at the expense of the beekeeper.

The rapid expansion of agricultural areas is threatening the existence of our wild pollinating insects. This is true of one of the most efficient alfalfa pollinators, *Nomia melanderia* Ckll., known as the alkali bee, according to observations in an alfalfa-seed district near Wapato, Wash. This district had been under cultivation only 3 years, but harrowing had so disturbed the nesting sites that *Nomia* bees returning from the fields were disorganized and disoriented. Although populations were still high during bloom, and they were apparently responsible for the heavy set of alfalfa seed pods found, suitable nesting areas were limited. The practice of applying DDT to blossoming fields in the middle of the day is also contributing to the destruction of these bees. It is obvious that remedial measures are needed to prevent the problem of pollination from becoming increasingly acute.

Experiments conducted in cooperation with the Horticultural Department of the University of California have shown that certain kinds of pollen collected by bees remain viable for more than 6 months when kept in a freezing chamber. These studies give promise not only of lessening the cost of pollination but of improving it, particularly where adverse conditions prevail, such as unfavorable weather or too few insects.

More Bees Mean More Seed

An average yield of 896 pounds of recleaned seed per acre was obtained from an alfalfa field of 132 acres on which five or six colonies of bees per acre had been used for pollinating purposes in an experiment in California conducted in cooperation with State agencies, the owner of the crop, and a beekeeper. At the beginning of bloom 264 colonies were scattered in rows through the field, but it was noted that adequate pollination was being obtained for the most part only close to the hives. Thereupon more bees were scattered in the field wherever flowers seemed to be neglected, until finally no plants were more than 300 feet from a hive and the total number of colonies exceeded 700. The basis for recompensing the beekeeper was unique. Under the terms of a contract drawn up at the beginning of the experiment, he placed two colonies per acre in the field without charge and received a fixed sum for each additional colony the seed producer requested during the season plus an allowance for all recleaned seed produced in excess of 400 pounds per acre. The beekeeper's honey crop was negligible.

The efficiency of insects in pollinating various plants depends on their rate of activity as well as on the number of insects present. For example, in 1 minute honey bees visited various clovers at the following rates: Alsike clover, 30.5 florets on 8 racemes; mammoth red clover, 8.1 florets on 2.3 racemes; medium red clover, 12 florets on 3.7 racemes; Hubam sweetclover, 41.4 florets; and heartsease, 37.6 florets. The habit of visiting only a portion of the florets on each raceme contributes to the chance of cross-pollination.

Self-tripping and self-pollination do not occur in red clover blossoms. Insects are required to perform both these functions if seed is to be produced, according to studies made in Ohio. In pollinating a red clover floret a honey bee approaches the blossom over the keel and forces its head down directly between the keel and the standard

petal. The fore and middle pairs of legs clutch and claw at the wings of the floret to pull them and the keel away from the standard, thus tripping the flower. This tripping exposes the stigma and anther, which contact the bee on the posterior ventral side of the head where it joins the thorax. Pollen is deposited and accumulated in this area and carried to the next blossom. Bees were not observed to use their mouth parts in collecting pollen from red clover.

New Laboratory To Investigate Effect of Insecticides on Pollinating Insects

A laboratory for the full-time study of the effect of various insecticides on bees was established in September 1949 at Tucson, Ariz. Special attention is being paid to the effect of commercial applications of new insecticides, by airplane and other means, on extensive tracts of melons, alfalfa, and other crops dependent on insects for pollination. This study is being conducted in cooperation with State and local agencies with funds authorized by the Research and Marketing Act.

Breeder Queen Bees Now Available

Breeders of queen bees have been given an opportunity to buy artificially inseminated breeding queens of selected lines of stock used in the Bureau's work. The queens are produced by the Bureau, but their sale is handled by the Honey Bee Improvement Cooperative Association. The queen breeder can cross the progeny of these selected queens with his own stock to produce hybrid queens for use by the commercial beekeeper.

About 1,300 hybrid queens were produced and distributed for test purposes in lots of 25 or more to beekeepers throughout the country, in connection with the bee-breeding project being conducted on Kelleys Island in Lake Erie in cooperation with this association.

CONTROL OF PLANT DISEASES

White Pine Blister Rust

Ribes eradication advanced

Federal, State, and private agencies cooperating in white pine blister rust control removed over 18 million ribes bushes from 1,443,000 acres during the calendar year 1949. About two-thirds of this work was follow-up on partially protected areas, and the remainder consisted in initial removal of ribes on unprotected stands. Control of the disease was achieved on areas totaling 874,000 acres. With this acreage added to that already on maintenance, about half the 28 million acres of blister rust control area are now safe for the production of white pine. At the peak of the season 3,870 temporary employees were removing ribes and 66 camps were in operation in western forest areas to carry on the field work.

Blister rust protection was maintained around 16 nurseries containing millions of young white pines for forest planting by removal of 32,000 ribes bushes in their environs. More than 5,000 white pine trees, mostly in plantations, were saved from destruction by blister rust by cutting out the diseased parts. State and local agencies par-

ticipated in the control program to protect white pine on lands in State and private ownership.

Contracting ribes eradication to individuals bidding on this work was undertaken in western forests where working conditions were suitable for this method. Cooperating agencies issued 165 contracts for work on 23,378 acres. About 26 percent of the acreage in the sugar pine and 5 percent in the western white pine region were worked under contract procedure. The cost was less than if it had been done with temporary labor from seasonal camps. Greater use will be made of this method as more bidders become qualified by training and experience to undertake contracts for ribes-eradication work.

Chemicals used to destroy ribes

The use of 2,4-D and 2,4,5-T for destroying ribes was continued in the western white pine and sugar pine regions. Over 3 million ribes bushes on 3,258 acres were treated with these chemicals, chiefly in scattered locations with 500 or more bushels to the acre. Chemical treatment was used on 1.4 percent of the acreage worked in the sugar pine region and on 4.2 percent in the western white pine region. There is some regeneration of ribes on treated areas from sprouts and seedlings. These bushes are easily killed with a light dosage of chemical applied within 1 to 3 years after the initial treatment. The use of chemicals permits more rapid coverage of work areas, and is cheaper than hand pulling where there are large numbers of bushes. This method of control is used wherever it is the most practical and least costly.

Extensive use was made of 2,4,5-T for destroying ribes in the forests of northern Idaho and in Mount Rainier, Glacier, and Yellowstone National Parks. Improved 2,4-D formulations containing summer oil emulsion and a sticker-spreader were devised for work on *Ribes roezli* and *R. nevadense* in California. The effectiveness of the basal-stem treatment of upright types of ribes was demonstrated further in test plots and by a practical methods test on *R. cereum*. Costs have been reduced with recently developed methods of treating ribes with 2,4-D or 2,4,5-T in ester form dissolved in Diesel oil and applied only to the intact basal stems.

The test plots on the Sierra National Forest in California sprayed with 2,4-D by helicopter in 1948 were checked in 1949. At least 75 percent of the Sierra gooseberry bushes on five of the plots were killed. There was little or no damage to conifers with 2,4-D in acid form at dosages of 1 pound or less an acre. When the dosage was increased to 1½ pounds an acre and oil used as the diluent, several yellow pine and sugar pine trees under 20 feet in height were injured. Improved helicopters for high-altitude work and more effective herbicides hold considerable promise for future use of this method in treating certain types of cutover areas.

Improved formulations of 2,4-D and 2,4,5-T have been devised which are effective in eradicating species of *Ribes* heretofore resistant to available herbicides—including *acerifolium*, *laxiflorum*, *montigenum*, *coloradense*, *setosum*, and *triste*, as well as certain resistant strains of *roezli* occurring on the Plumas and Lassen National Forests. They have also minimized sprouting of *roezli* during the midseason.

Rust spread in white pine regions

Blister rust was reported for the first time on white pines in three counties in Montana, and on ribes in two counties in Wyoming and one in Idaho. The disease on pines, which is moving southward, is now about 2 miles north of Yellowstone National Park. The infection on ribes extends the rust 100 miles east and 50 miles south to a point 12 miles west of Lander in Fremont County, Wyo.

In the sugar pine region there was no long-distance spread and no significant damage in pine areas where ribes bushes had been removed. Within the infected portions of this region and also outside of control areas the rust was well entrenched, was developing progressively, and in some sites had already caused severe damage to immature trees. Rust on ribes was reported for the first time in Mendocino National Forest, Colusa County, Calif. Infected sugar pines found on the southern end of the Eldorado National Forest in the Sierras advanced the rust southward about 11 miles. The finding of numerous cankers of recent origin on pine in the Trinity National Forest indicates a rapid build-up of the disease in favorable sites. A similar condition is developing on parts of the Shasta National Forest.

Pine infection was found for the first time in seven additional counties in the North-Central States—one in Illinois, two in Minnesota, and four in Wisconsin. In the southern Appalachian region rust on ribes was reported for the first time in one additional County in Tennessee, one in Georgia, and two in North Carolina. It was reported on white pine for the first time in one county in West Virginia and in three counties in North Carolina. Nearly all pine infection found south of Virginia is outside of established control areas.

Some western white pine resistant to blister rust

The possibility of natural resistance to blister rust in western white pine has attracted considerable interest, because planting may be used to some extent in future management of this species. Several agencies are cooperating in a study to determine the degree of natural resistance in this species and whether there are physiologic races of the fungus. The long-range objective is to provide resistant trees for seed collection in several localities in the western white pine type. Thus far 14 trees that appear to be risistant to blister rust have been located in infection centers. These trees are free of cankers, while others next to them have from 100 to 1,000. Scions from these trees have been grafted on 5-year-old nursery transplants for testing for rust resistance, and efforts are being made to find additional resistant trees.

Barberry Eradication To Control Stem Rust

Eradication work expanded

Barberry eradication to control stem rust of wheat was expanded during the year. This was possible because increased funds were made available by the Federal Government and 10 States, particularly Pennsylvania, Nebraska, Illinois, and Washington. During the first 6 months of this fiscal year 270 more properties were cleared of barberry bushes, 2,519 more square miles were worked, and 1,138 more former bush locations were inspected than in the same period of the previous

year. The rework program was stepped up materially and some areas were worked that had not received attention for 8 years.

During the calendar year 1949 rework was done on 19,314 square miles, and initial work on 5,896 square miles. Over 9½ million barberry bushes were removed from 3,426 new properties and 2,289 reinfested properties in 214 counties. No bushes were found on 6,715 previously infested properties that were reinspected.

About 84 percent of the area in the 18 States cooperating in barberry eradication is now free of rust-spreading barberry plants and can be kept in that condition by a small maintenance program. In the remaining 168,598 square miles many barberry-infested sites require one or more workings at intervals of about 5 years to free them of these bushes. Within this area more than 79,000 properties are or have been infested.

New spray equipment used for barberry eradication

Power spray equipment was used for the first time on a practical scale for applying chemicals to control stem rust. Compressed-air spray equipment was developed and used in treating large areas of native barberry bushes with 2,4-D and 2,4,5-T. It consists of a 40-gallon tank equipped with take-offs for two hose lines 200 feet long. Each spray unit is mounted on a 4-wheel-drive truck, which can be driven close enough to barberry-infested sites to permit chemical treatment. A small portable sprayer of the same type was used for treating scattered patches. Field trials indicate that by the use of this method the eradication of native barberry bushes may be accomplished in about one-fifth the time and the cost reduced by 60 percent as compared with methods previously used.

Dangerous races of stem rust appear on barberry

Stem rust was light in 1949. The disease caused some damage to wheat in barberry-infested areas in Pennsylvania, Virginia, and West Virginia. There was also some damage to wheat in Texas and northward in western Oklahoma, Kansas, Nebraska, and into south-central South Dakota. Stem rust was heavy on wheat in northern Mexico, and it appears to have been carried northward from that area into the United States.

Races 56, 17, and 38 of stem rust were the most prevalent throughout the Wheat Belt. For 11 consecutive years they have comprised more than 90 percent of the rust collected from wheat and identified. Race 56 was confined almost entirely to the Great Plains. East of the Mississippi the 3 races were uniformly prevalent. In contrast, 35 different races were identified from 59 collections taken from barberry bushes. In addition 43 races and biotypes of stem rust were identified from collections of wheat growing near barberry bushes in Lebanon County, Pa., in 1949. The most virulent races, including 11 and 15, were identified from these collections. Barberry is the breeding medium for new races and a constant menace to the Nation's crop of wheat, oats, barley, and rye in the development and dissemination of new and virulent races of stem rust.

Quarantine 38 revised

Black Stem Rust Quarantine 38 was revised, effective May 1949, to obtain more effective regulation of interstate movement of barberry

bushes and give increased protection against reinfestation of barberry-free areas with rust-susceptible plants. Applications for inspection for interstate movement of approved rust-resistant barberry bushes were received from 259 nurseries. Only one nursery failed to qualify.

Diseases of Elm

Dutch elm disease found in many new areas

The Dutch elm disease fungus was found during the year in 4,157 specimens of bark or twigs from 11 States and the District of Columbia. Fifty-one infected elms were found in and around the District of Columbia and up the Potomac River, as compared with 24 in 1949. Infected trees were found for the first time in central Pennsylvania, and also at several locations in the northwestern part of that State. Dutch elm disease in epidemic form was found near Port Clinton, Ohio, and three diseased elms were discovered at Fort Wayne, Ind. Canadian officials reported this disease near the Vermont-Quebec border and at Windsor, Ontario. Infected elms were found at Rutland, Vt., and for the first time in 46 towns in Massachusetts.

The smaller European elm bark beetle, an important carrier of the Dutch elm disease, was identified at Kansas City, Mo., but no Dutch elm disease was found in the cultured specimens. This beetle was also identified for the first time in Maine. Two sexual strains of *Ceratostomella ulmi*, the Dutch elm disease fungus, were detected among 53 specimens from various parts of the United States. One strain was found at widely separated points, but the other exclusively in the vicinity of Indianapolis, Ind. The two strains were found together in five specimens from Connecticut, New Jersey, Ohio, and Colorado.

In 1948 and 1949 about 250 property owners, the New Jersey Department of Agriculture, Princeton University, and town agencies participated in a program to control Dutch elm disease in Princeton, N. J. Each year approximately 2,500 elms were sprayed twice before the foliage appeared with 2-percent DDT, and in midsummer with 1-percent DDT. Both mist blowers and high-powered hydraulic sprayers were used. While it is too early to assess the value of this community-wide attack on the Dutch elm disease problem, in 1949 the number of diseased trees in the borough of Princeton was only about 10 percent of that in surrounding untreated areas.

Phloem necrosis of elm controlled with DDT sprays

Definite evidence that DDT sprays will control phloem necrosis of elm has been obtained after 5 years' experiments in Ohio. That the virus causing this disease is transmitted by an insect was suspected long before the vector was identified. An experiment was begun in 1945 to determine the possibility of controlling the unknown vector through the application of DDT to healthy street trees. Since it was not known when during the growing season the vector might be present, the test trees were sprayed at regular intervals from April to September. In 1945 and 1946 six applications were made and since then five have been made each year. For the first 2 years of the experiment no difference in incidence of disease between sprayed and unsprayed trees was noticed. Since that time, however, disease in the sprayed trees has decreased markedly, while among unsprayed trees it has continued to increase until it is now in an epidemic state.

In 1947 the leafhopper *Scaphoides luteolus* Van D. was found to be the vector of this disease.

Diseases of Peach

Insect carrier of western X disease discovered

The leafhopper *Colladonus geminatus* (Van D.) has been found to carry the virus that causes X disease of peach in the Western States. The first indication that this leafhopper can transmit western X disease was obtained at The Dalles, Oreg., where one small peach tree exposed to leafhoppers that had fed on both diseased cherry and peach trees developed typical symptoms of the disease. In subsequent greenhouse experiments made by cooperating entomologists at the Tree Fruit Experiment Station at Wenatchee, Wash., the same leafhopper was found to transmit this disease to six small Lovell seedling peach trees. The first symptoms developed 46 days after the healthy trees had been exposed to the viruliferous leafhoppers. In one of the experiments a single leafhopper was able to infect a healthy tree. These studies are being carried on in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering and the agricultural experiment stations of Washington, Oregon, and Utah, with funds authorized by the Research and Marketing Act of 1946.

Inspection reveals spread of peach mosaic in Arkansas

The first mosaic-infected peach tree discovered in Arkansas was found in Pike County in 1947 and immediately destroyed. Intensive inspection in that State in 1948 revealed no infected trees, but in 1949 five trees on three properties were found to have symptoms of mosaic disease. Three were on the same property found infected in 1947 and the other two were in adjacent Howard County. Inspections conducted in Arkansas in 1950 to June 30 disclosed 189 mosaic-infected trees on 42 properties in Howard, Hempstead, and Pike Counties, 180 of these trees being in Howard County. Prompt action was taken to destroy all these trees. Recollection of the virulent outbreak of this serious disease in Colorado in 1935 emphasized the importance of forthright measures to suppress this incipient outbreak in Arkansas.

During the calendar year 1949 more than 10 million orchard trees on 5,621 properties in 190 counties of 23 States were inspected for phony peach and peach mosaic diseases. Phony infection was found in seven additional counties and mosaic in four. No phony disease was found for the third consecutive year in seven previously infected counties and no mosaic in two, and the States therefore released quarantine restrictions. Increases in phony disease were shown only in restricted areas of the heavily infected States of Alabama and Georgia, where the weather was unusually mild during the previous winter, resulting in an abnormal period of dormancy. Mosaic increases were noted in all infected States except New Mexico and Oklahoma, but they were minor and are attributable to seasonal fluctuations in incidence.

In the first 6 months of 1950 inspections within the regulated areas were made of the environs of 254 nurseries growing more than 1.5 million peach trees, and outside the regulated areas of the environs of 175 nurseries growing nearly 7 million peach trees. One nursery in the phony peach regulated area of Georgia growing 7,000 trees

failed to meet the State certification requirements. The trees in 25 orchards given as budwood sources, and their environs, in 10 counties of the peach mosaic regulated areas were also inspected. Two of these orchards, both in Howard County, Ark., were found to be ineligible for certified budwood cutting.

Season of peach mosaic spread in southern California determined

The natural spread of peach mosaic, a serious virus disease of peach in the Southwest, may go on throughout the growing season, but is most likely to occur in May and June, according to experiments conducted in southern California. In 1949 several lots of about 100 potted trees were exposed to infection in an area of rapid spread for periods of 2 months each from March to November. Although most of the trees showing symptoms of peach mosaic in the spring of 1950 had been exposed during May and June, symptoms also appeared in three trees that had been exposed later in the season. None of the many check trees that were maintained contracted the disease. These experiments were carried on in cooperation with the California Department of Agriculture and Agricultural Experiment Station and the Bureau of Plant Industry, Soils, and Agricultural Engineering.

Vectors of Stunt Diseases of Berries Identified

The insect vector of strawberry yellows was formerly thought to be a single species, but recent studies show that two closely related forms of the genus *Capitophorus* have been confused. It is necessary to distinguish between these species in order to tell whether either or both are capable of transmitting the disease.

Taxonomic studies showed that two leafhoppers of the genus *Scaphytopius* were being confused in the course of vector tests of blueberry stunt disease in New Jersey, and that species were being confused in a search for a vector of a virus disease of corn in Mexico. Basic information on the identity, distribution, and phylogenetic relationships of leafhopper vectors of virus diseases has been made available through the publication of a comprehensive work on the generic classification of the Nearctic species.

Citrus Canker Resurvey Extended to Louisiana

A resurvey for citrus canker in cooperation with the State of Louisiana was made during the fall of 1949 in 10 parishes, including properties from which canker had been eradicated in previous years. More than 13,000 trees on 655 properties were inspected without finding the disease. The trees were principally satsumas and seedlings of other types of citrus. Some were as much as 30 feet high and 60 years old, and many were badly infested with scale insects and whiteflies, and covered with sooty mold and red fungus, all of which made inspection difficult. No citrus trees were found on 6 of the 15 properties on which infections were found between 1935 and 1940.

The resurvey of formerly infected and adjacent areas in Texas, begun in September 1947, was continued in nine counties from September 1949 through March 1950, but with negative results. No citrus canker has been found in Texas since January 1943.

Southeastern States Surveyed for Camellia Flower Blight

The discovery in 1948 that camellias on a property in Atlanta, Ga., were infected with camellia flower blight prompted plant quarantine officials in the Southeastern States to request cooperation of the Bureau in a survey to determine whether this disease exists elsewhere in the Southeast. This disease has been known to be present in California since 1938 and has recently been found in Oregon. Nearly 2 million plants in 159 counties of Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Texas were examined from December 1949 through March 1950. Inspections were also made of greenhouse-grown camellias in Nassau County, N. Y. Properties not heretofore known to be infected were found at Winnabow, N. C., and Shreveport, La., and additional infected blooms were found on the property in Atlanta known to be infected.

BASIC PUBLICATIONS TO AID INSECT INVESTIGATIONS

In recent years there has been a rapidly growing demand for a comprehensive work on the classification of mites, not only from mite specialists but also from students and investigators in the fields of entomology, zoology, parasitology, medicine and public health, and agriculture. This interest has resulted particularly from the recognition of mites as carriers of human diseases and from the creation of new problems in the control of plant-infesting mites that have followed extensive use of DDT and certain other new insecticides. The manuscript of such a book, supported by nearly 400 illustrations, has been completed and will be published outside the Department.

Bureau specialists, in cooperation with a number of other specialists attached to outside institutions, have completed another large taxonomic work. This is a synoptic catalog of the insect order Hymenoptera, which comprises the bees, wasps, ants, sawflies, wood wasps, gall wasps, and insect parasites that are of importance in the biological control of various pests. Approximately 20,000 different species are treated. This publication, Agriculture Monograph No. 2, will be an indispensable guide to authoritative information on the classification, nomenclature, synonymy, distribution, hosts, and habits of these economically important insects.

Another valuable working tool published during the year is Insect Enemies of Eastern Forests, issued by the Department as Miscellaneous Publication 657. In this handbook of 679 pages all the important forest insects known to occur in the United States east of the Rocky Mountains are discussed, with keys, discriptions, and general control methods. This is a companion volume to Insect Enemies of Western Forests, Miscellaneous Publication 273, issued in 1939 and now in process of revision.

BUREAU WORKERS PARTICIPATE IN LOCAL MEETINGS

An important part of the work of this Bureau is to acquaint the public with the results of its research and the work under way on the control of insects and plant diseases. Not only is this done through publications, the press, and radio, but by participation in meetings of various kinds. Bureau workers are frequently asked

to speak before local organizations such as the Grange, farm bureaus, chambers of commerce, civic organizations, garden clubs, 4–H clubs, and crop-growing associations. Meetings of farmers and other groups are often arranged by county agents, and Bureau offices may be asked to display exhibits at county and State fairs. Where programs are conducted to eradicate or prevent the spread of an insect or disease or to combat outbreaks, these meetings provide an important additional means of acquainting the public with the need for action and what measures are most effective.

During the year Bureau workers took part in at least 2,300 such meetings, which were attended by a total of about 350,000 people. Employees on blister rust control participated in 958 meetings with a total audience of 209,900, and those engaged in barberry eradication took part in 103 meetings with an attendance of 4,600. At 55 meetings in New England and nearby States Bureau men told approximately 45,300 people what is being done to combat the gypsy moth and how the public can cooperate most effectively in this program. In the war against grasshoppers and Mormon crickets in the Western and Midwestern States, 570 meetings and demonstrations were held before audiences totaling nearly 40,000. Workers on white-fringed beetle control in the Southern States held 366 meetings where the total attendance was more than 20,300. More than 19,000 people were present at 159 meetings held in Louisiana in connection with an educational campaign to eradicate the sweetpotato weevil. (See p. 23.) Workers from a single field station concerned with the control of cotton insects held 33 meetings in the spring of 1950 to acquaint 6,600 farmers with new measures.

FOREIGN PLANT QUARANTINE ACTIVITIES

Extensive foreign travel and continued large-scale international commerce in plants and plant products made the task of protecting our agriculture from foreign pests increasingly difficult. Travel to Europe was unusually heavy because of the Holy Year pilgrimage. Vehicular traffic from Mexico, much of which had passed through the areas of that country infested with citrus blackflies, was the heaviest on record. The availability of approved treatments for fruits that would otherwise be prohibited entry because of pest risk and the worldwide demand for United States dollars resulted in large quantities of fruits being imported from several countries that had not previously shipped them to our markets. Quarantine restrictions affecting the importation of nursery stock were strengthened, and marked progress was made in the cooperative program with the States whereby certain plants are grown for a period under postentry quarantine to insure freedom from pests that may have escaped detection at the time of entry. Increased commercial interest in importing cotton lint, linters, and wastes for supervised utilization in northern mills in lieu of fumigation made it necessary to provide for more careful supervision of this activity.

As in past years, other Federal agencies, particularly the Bureau of Customs, the Immigration and Naturalization Service, the Public Health Service, and the Department of Defense, cooperated in the foreign plant quarantine program and contributed materially to its success.

Inspection of Carriers

Ocean traffic was again heavy during the year. A total of 45,000 vessels arrived at maritime ports of entry, 43,000 of which were given plant quarantine inspection. One ship out of four was found to be carrying prohibited plant material. The thousands of insects and plant diseases intercepted from this material included many of the world's most important agricultural pests. Vessels with returned military equipment continued to arrive from Pacific areas where the giant African snail occurs. Through the cooperation of the steamship companies and importers, cargoes infested with the snail were cleaned and fumigated to prevent its introduction. Arrangements were made with the Army whereby returned equipment is now cleaned and fumigated prior to arrival. No living snails have been found with cargoes so safeguarded.

In Hawaii 22,300 pieces of baggage and automobile trunks were inspected and sealed prior to departure for the mainland on surface vessels. Over 557,000 packages of cut flowers and leis were examined, 3,200 of which were rejected for pest reasons and 359,000 treated as a condition of shipment to the continental United States. The approval of treatments for additional commodities greatly increased the volume of fruits and vegetables certified for movement after treatment. A total of 665 shipments, including 98,000 containers, were certified on this basis. In Puerto Rico 1947 shipments, consisting of 19,000 containers of fruits and vegetables, were certified for movement to the mainland.

Inspection of aircraft again prevented the entry of many injurious pests, some of which would threaten the agricultural economy of large sections of the United States should they become established here. During the year 57,400 planes were inspected at ports of entry, including 3,000 arrivals from the mainland inspected in Hawaii. Nearly 17,000 planes were found to be carrying contraband plant material, much of which was infested or infected with destructive pests. Interceptions of foreign fruit flies from airborne host material were particularly heavy.

Planes destined to the mainland from Hawaii and Puerto Rico were again given preflight inspection and treated with DDT aerosol prior to departure. Preflight clearance was given to 3,321 such planes together with 220,500 pieces of baggage in Hawaii and to 3,722 planes and 230,000 pieces of baggage in Puerto Rico. Prohibited plant material was removed from about half the planes inspected in each place. This is the first full year that this program has been in effect in Puerto Rico.

Increased vehicular traffic from Mexico added to the problem of safeguarding against the entry of the citrus blackfly and other pests of that country. Nearly 8,400,000 vehicles and 3,166,000 pieces of baggage entered and were inspected during the year. The threat from the citrus blackfly associated with this traffic is especially serious, as the infested zones, which are only a few hours' drive from the border, are linked to our citrus-production areas by paved highways. Inspection service was maintained on a 24-hour-a-day basis at strategic ports of entry, and infested citrus foliage was intercepted on a number of occasions.

A total of 3,477 pullman and passenger coaches were inspected at the Mexican border, and 68,753 freight cars were examined in Mexico prior to entry. The cooperative work being conducted in Mexico made it possible to reduce greatly the number of freight cars fumigated as a condition of entry, only 1,691 cars having been fumigated during the year. The cooperative program between this Bureau and the Mexican Department of Agriculture to protect Baja California from pests of the mainland of Mexico was reorganized and materially strengthened.

Inspection of Mail

Studies during the year indicate that foreign parcel post is one of the most likely avenues of entry for alien pests. Nearly 2 million parcel-post packages were examined, of which 3,561 were found to contain prohibited plant material and 3,789 plants and plant products were released under permit. A number of serious pests, including the golden nematode in soil on roots of shamrocks from Ireland, were in-intercepted from material moving in the mails. A total of 377,550 mail packages were examined in Hawaii prior to dispatch to the mainland; 77,000 were opened for inspection. In Puerto Rico 97,600 packages were examined, 6,500 of which were opened prior to dispatch to the mainland. Arrangements were worked out with postal officials whereby sacks of mail examined in Puerto Rico are conspicously marked to obviate the necessity of reinspection after arrival in New York. This procedure has resulted in a considerable saving of manpower.

Inspection of Imported Plant Products

The growing interest of foreign shippers in marketing plants and plant products in the United States again resulted in heavy importations of plant material under permit. More than 243,300,000 crates, boxes, bales, bushels, bunches, and other units were inspected at ports of entry and treated or otherwise safeguarded when pest conditions so warranted. This material included nursery stock, plants, seeds, fruits, vegetables, cotton, cotton products, cereals, and fibers. In addition, millions of small lots of plant material brought in from Mexico were inspected but not recorded. Large quantities of fruits were imported subject to treatment, which would otherwise have been prohibited because of risk of infestation by fruit flies. They included deciduous fruits from South Africa and Australia and citrus fruit from Palestine. The trade also took advantage for the first time of the provision for the entry of citrus fruit under vapor-heat treatment.

The Department imported 861 shipments of plants, seeds, and other propagating materials for scientific and experimental purposes. These materials were examined and treated, if necessary, at the inspection house in Washington, D. C. Plants considered capable of harboring pests not apparent at the time of entry were grown for a period under quarantine, during which time they were regularly examined.

Final inspection prior to release was made of 44,805 exotic plants and 2,160 budsticks and cuttings grown by the Department under

quarantine conditions. Regular inspections were also made of plant materials grown in the plant introduction and propagating gardens of the Bureau of Plant Industry, Soils, and Agricultural Engineering. Inspections at the gardens in Coconut Grove, Fla., and Mandan, N. Dak., were made by State officials cooperating with the Bureau, inspections at Chico, Calif., were made jointly by State and Bureau officials, and material distributed from the District of Columbia, Beltsville, Md., and Savannah, Ga., was examined by Bureau inspectors. During the year 67,000 plants, 5,000 budsticks and cuttings, 7,800 roots and tubers, and 1,800 lots of seeds were inspected prior to shipment from these gardens.

Plants and Pests Intercepted

The best measure of protection from foreign pests given the country is the volume of unauthorized plant material and the number of insect pests and plant diseases intercepted. During the year nearly 149,000 interceptions of prohibited or restricted plants and plant products were made, 44,000 of which were taken from planes. Additional interceptions were made by customs officers at Mexican and Canadian border ports, where there is not sufficient traffic to warrant the services of a plant quarantine inspector.

Plant quarantine inspectors made 22,186 interceptions of plant pests, including 15,688 of insects and 6,498 of diseases as well as thousands of insects and plant diseases of little or no economic importance.

Pests arriving on airplanes present a special threat. Interceptions from aircraft totaled 4,092, most of which were from host-plant materials although a few pests arrived as stowaways. Among them were an unusually large number of fruit flies—the Mexican, West Indian, and oriental fruit flies, as well as five other related species. Among other important insect pests taken from airplanes were three species of whiteflies, the mango weevil, a destructive bean-pod borer, the pink bollworm, and an important lepidopterous pest of grapes.

Disease organisms intercepted included citrus canker, sweet orange scab, rusts of spruce, pine, cherry, acacia, rhododendron, and scilla, the Curvularia disease of gladiolus, the Sigatoka disease of banana, the black spot of citrus, a Cercospora leaf disease of pine, brown rot of pome fruits, twig canker of grapes, and Australian citrus scab. Interceptions of nematodes included the golden nematode of potatoes and one reported as a pest of wheat.

Plant Material Grown Under Postentry Quarantine

During the first full year that the provision for growing certain imported plants under detention has been in effect, 583 shipments comprising 1,127,151 plants were imported subject to postentry quarantine. The plants represented 40 genera and were destined for 38 States. Frequent contacts were made with State officials, and 160,000 plants being grown under quarantine were inspected in cooperation with them. Considerable variation was found in inspection procedures and quarantine methods, but in general State officials were much interested in the postentry detention program. In several in-

stances recognized plant pests and suspected virus diseases were found and steps were taken to prevent their establishment by fumigation, roguing, or other comparable actions. In order to familiarize them with the pests that might be found on the plants under observation, 47 circulars describing these pests were prepared and distributed.

Treatment of Imported Plant Material

In addition to the fruits and vegetables treated in transit, in the Territories of Hawaii and Puerto Rico and in Mexico prior to entry, it was necessary to fumigate or otherwise treat large quantities of plants and plant products upon arrival because of the pest risk involved. During the year nearly 850,000 bales of cotton lint, linters, and bagging, 9,324,000 pounds of cottonseed cake and meal, and 25,500 cotton samples were fumigated. Treatment was also required as a condition of entry for 60,000 cases of fruits and vegetables; 53,500 containers of chestnuts, cipollini, and pigeonpeas; 350 bales of broomcorn; 4,510,000 units and 7,264 containers of plants, cuttings, bulbs, roots, and other propagating material; 52,200 pounds and 67,300 containers of seeds and 19,000 lots of other miscellaneous plant products. A total of 5,000 pieces of returned military equipment were cleaned or fumigated because of the presence of the giant African snail.

Certification for Export

The exportation of large quantities of surplus potatoes to Europe, particularly to Portugal and Spain, increased the demand for inspection and certification of agricultural material for export. A total of 13,916 export certificates were issued, covering 7,533,000 containers of domestic plants and plant products inspected and certified to meet the sanitary requirements of the importing countries. This is an increase of more than 3 million containers over the number certified last year. The certificates were issued at 42 ports and covered 101 commodities consigned to 111 foreign countries.

TRANSIT INSPECTION

Regular transit-inspection activities were conducted during 1949 continuously at 10 terminals and seasonally at 4 by a total of 25 permanent, part-time, or seasonal inspectors, assisted by 8 part-time State collaborators. In the South white-fringed beetle inspectors performed transit-inspection work at 19 points on a part-time basis in connection with their other duties. In California State inspectors gave assistance by reporting violations of Federal domestic plant quarantines and taking appropriate action.

During the year ending May 31, 1950, a total of 1,542,614 shipments were inspected, and 1,257 were found moving in apparent violation of Federal domestic plant quarantines to destinations in 42 States, the District of Columbia, and Canada. These shipments were either returned or, when practicable, examined, certified, and allowed to proceed to destination. Transit inspectors also reported 405 apparent infringements of State nursery inspection or quarantine regulations.

INSPECTION SERVICE IN DISTRICT OF COLUMBIA

During the 12-month period ended May 31, 1950, examination was made of 43,905 shipments of plants entering the District of Columbia to determine whether they were certified and free from insect pests and plant diseases. Forty-three shipments were found to lack the required State certification, and 4 were destroyed or returned to the sender because pests were present. During the same period certificates were issued for 873 shipments containing 35,334 plants sent from the District of Columbia to 43 States, Alaska, Puerto Rico, and the Virgin Islands.

In these shipments inspectors found 21 kinds of insect pests, 2 species of nematodes, and 14 plant diseases. Diseased or infested plants were treated when possible, destroyed, or returned to the shippers.

Sixty-one trucks bringing potted plants or nursery stock into the District were intercepted. Several of these trucks belonged to itinerant peddlers who did not have certificates for their stock and could not furnish evidence that it had been inspected. Consequently, they were ordered not to sell their stock in the District.

ORGANIZATION OF THE BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

Chief of Bureau	A. S. Hoyt.
Assistant Chief (Regulatory)	S. A. Rohwer.
Assistant Chief (Research)	F. C. Bishopp.
Assistant Chief (Control)	W. L. Popham.
Assistant Chief (Administration)	R. A. Sheals.
Special Assistant to the Chief	H. L. Haller.
Division of Finance and Business Administration	B. Connor.
Division of Personnel	W. L. Leffler.
Division of Insect Survey and Information	G. J. Haeussler.
Division of Fruit Insect Investigations	B. A. Porter.
Division of Fruit Fly Investigations	A. C. Baker.
Division of Mexican Fruit Fly Control	P. A. Hoidale.
Division of Japanese Beetle Control	E. G. Brewer.
Division of Forest Insect Investigations	James A. Beal.*
Division of Gypsy Moth Control	J. M. Corliss.
Division of Plant Disease Control	J. F. Martin.
Division of Cereal and Forage Insect Investigations	C. M. Packard.
Division of Truck Crop and Garden Insect Investigations	W. H. White.
Division of Cotton Insect Investigations	R. W. Harned.
Division of Pink Bollworm Control	L. F. Curl.
Division of Bee Culture	J. I. Hambleton.
Division of Insects Affecting Man and Animals	E. F. Knipling.
Division of Insect Identification	C. F. W. Muesebeck.
Division of Foreign Parasite Introduction	C. P. Clausen.
Division of Control Investigations	C. P. Clausen.
Division of Insecticide Investigations	R. C. Roark.
Division of Foreign Plant Quarantines	E. R. Sasscer.
Division of Domestic Plant Quarantines	R. G. Richmond.
Division of Grasshopper Control	Claude Wakeland.
Division of Golden Nematode Control	H. L. Smith.

*Effective Aug. 20, 1950.

○